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This handbook for the port of Toulon, one in a series of severe weather guides for Mediterranean ports, provides decision-making guidance for ship captains whose vessels are threatened by actual or forecast strong winds, high seas, restricted visibility or thunderstorms in the port vicinity. Causes and effects of such hazardous conditions are discussed. Precautionary or evasive actions are suggested for various vessel situations. The handbook is organized in four sections for ready reference: general guidance on handbook content and use; a quick-look captain's summary; a more detailed review of general information on environmental conditions; and an appendix that provides oceanographic information.

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SEVERE WEATHER GUIDE MEDITERRANEAN PORTS

8. TOULON

CONTENTS

FOREWORD

This handbook on Mediterranean Ports was developed as part of an ongoing effort at the Naval Environmental Prediction Research Facility to create products for direct application to Fleet operations. The research was conducted in response to Commander Naval Oceanography Command (CNOC) requirements validated by the Chief of Naval Operations (CNO).

As mentioned in the preface, the Mediterranean region is unique in that several areas exist where local winds can cause dangerous operating conditions. This handbook will provide the ship's captain with assistance in making decisions regarding the disposition of his ship when heavy winds and seas are encountered or forecast at various port locations.

Readers are urged to submit comments, suggestions for changes, deletions and/or additions to NOCC, Rota with a copy to the oceanographer, COMSIXTHFLT. They will then be passed on to the Naval Environmental Prediction Research Facility for review and incorporation as appropriate. This document will be a dynamic one, changing and improving as more and better information is obtained.

M. G. SALINAS
Commander, U.S. Navy

PORT INDEX

The following is a tentative prioritized list of Mediterranean Ports to be evaluated during the five-year period 1988-92, with ports grouped by expected year of the port study's publication. This list is subject to change as dictated by circumstances and periodic review.

1988 NO.	PORT
1	GAETA, ITALY
2	NAPLES, ITALY
3	CATANIA, ITALY
4	AUGUSTA BAY, ITALY
5	CAGLIARI, ITALY
6	LA MADDALENA, ITALY
7	MARSEILLE, FRANCE
8	TOULON, FRANCE
9	VILLEFRANCHE, FRANCE
10	MALAGA, SPAIN
11	NICE, FRANCE
12	CANNES, FRANCE
13	MONACO
14	ASHDOD, ISRAEL
15	HAIFA, ISRAEL
	BARCELONA, SPAIN
	PALMA, SPAIN
	IBIZA, SPAIN
	POLLENSA BAY, SPAIN
	VALENCIA, SPAIN
	CARTAGENA, SPAIN
	GENOA, ITALY
	LIVORNO, ITALY
	SAN REMO, ITALY
	LA SPEZIA, ITALY
	VENICE, ITALY
	TRIESTE, ITALY

1989	PORT
	SPLIT, YUGOSLAVIA
	DUBROVNIK, YUGOSLAVIA
	TARANTO, ITALY
	PALERMO, ITALY
	MESSINA, ITALY
	TAORMINA, ITALY
	PORTO TORRES, ITALY

1990	PORT
	BENIDORM, SPAIN
	ROTA, SPAIN
	TANGIER, MOROCCO
	PORT SAID, EGYPT
	ALEXANDRIA, EGYPT
	ALGIERS, ALGERIA
	TUNIS, TUNISIA
	GULF HAMMAMET, TUNISIA
	GULF OF GABES, TUNISIA
	SOUDA BAY, CRETE

1991	PORT
	PIRAEUS, GREECE
	KALAMATA, GREECE
	THESSALONIKI, GREECE
	CORFU, GREECE
	KITHIRA, GREECE
	VALETTA, MALTA
	LARNACA, CYPRUS

1992	PORT
	ANTALYA, TURKEY
	ISKENDERUN, TURKEY
	IZMIR, TURKEY
	ISTANBUL, TURKEY
	GOLCUK, TURKEY
	GULF OF SOLLUM

PREFACE

Environmental phenomena such as strong winds, high waves, restrictions to visibility and thunderstorms can be hazardous to critical Fleet operations. The cause and effect of several of these phenomena are unique to the Mediterranean region and some prior knowledge of their characteristics would be helpful to ship's captains. The intent of this publication is to provide guidance to the captains for assistance in decision making.

The Mediterranean Sea region is an area where complicated topographical features influence weather patterns. Katabatic winds will flow through restricted mountain gaps or valleys and, as a result of the venturi effect, strengthen to storm intensity in a short period of time. As these winds exit and flow over port regions and coastal areas, anchored ships with large 'sail areas' may be blown aground. Also, hazardous sea state conditions are created, posing a danger for small boats ferrying personnel to and from port. At the same time, adjacent areas may be relatively calm. A glance at current weather charts may not always reveal the causes for these local effects which vary drastically from point to point.

Because of the irregular coast line and numerous islands in the Mediterranean, swell can be refracted around such barriers and come from directions which vary greatly with the wind. Anchored ships may experience winds and seas from one direction and swell from a different direction. These conditions can be extremely hazardous for tendered vessels. Moderate to heavy swell may also propagate outward in advance of a storm resulting in uncomfortable and sometimes dangerous conditions, especially during tending, refueling and boating operations.

This handbook addresses the various weather conditions, their local cause and effect and suggests some evasive action to be taken if necessary. Most of the major ports in the Mediterranean will be covered in the handbook. A priority list, established by the Sixth Fleet, exists for the port studies conducted and this list will be followed as closely as possible in terms of scheduling publications.

RECORD OF CHANGES

CHANGE NUMBER	DATE OF CHANGE	DATE ENTERED	PAGE NUMBER	ENTERED BY

1. GENERAL GUIDANCE

1.1 DESIGN

This handbook is designed to provide ship captains with a ready reference on hazardous weather and wave conditions in selected Mediterranean harbors. Section 2, the captain's summary, is an abbreviated version of section 3, the general information section intended for staff planners and meteorologists. Once section 3 has been read, it is not necessary to read section 2.

1.1.1 Objectives

The basic objective is to provide ship captains with a concise reference of hazards to ship activities that are caused by environmental conditions in various Mediterranean harbors, and to offer suggestions for precautionary and/or evasive actions. A secondary objective is to provide adequate background information on such hazards so that operational forecasters, or other interested parties, can quickly gain the local knowledge that is necessary to ensure high quality forecasts.

1.1.2 Approach

Information on harbor conditions and hazards was accumulated in the following manner:

A. A literature search for reference material was performed.

B. Cruise reports were reviewed.

C. Navy personnel with current or previous area experience were interviewed.

D. A preliminary report was developed which included questions on various local conditions in specific harbors.

E. Port/harbor visits were made by NEPRF personnel; considerable information was obtained through interviews with local pilots, tug masters, etc; and local reference material was obtained (See section 3 references).

F. The cumulative information was reviewed, combined, and condensed for harbor studies.

1.1.3 Organization

The Handbook contains two sections for each harbor. The first section summarizes harbor conditions and is intended for use as a quick reference by ship captains, navigators, inport/at sea OOD's, and other interested personnel. This section contains:

A. a brief narrative summary of environmental hazards,

B. a table display of vessel location/situation, potential environmental hazard, effect-precautionary/evasion actions, and advance indicators of potential environmental hazards,

C. local wind wave conditions, and

D. tables depicting the wave conditions resulting from propagation of deep water swell into the harbor.

The swell propagation information includes percent occurrence, average duration, and the period of maximum wave energy within height ranges of greater than 3.3 feet and greater than 6.6 feet. The details on the generation of sea and swell information are provided in Appendix A.

The second section contains additional details and background information on seasonal hazardous conditions. This section is directed to personnel who have a need for additional insights on environmental hazards and related weather events.

1.2. CONTENTS OF SPECIFIC HARBOR STUDIES

This handbook specifically addresses potential wind and wave related hazards to ships operating in various Mediterranean ports utilized by the U.S. Navy. It does not contain general purpose climatology and/or comprehensive forecast rules for weather conditions of a more benign nature.

The contents are intended for use in both pre-visit planning and in situ problem solving by either mariners or environmentalists. Potential hazards related to both weather and waves are addressed. The oceanographic information includes some rather unique information relating to deep water swell propagating into harbor shallow water areas.

Emphasis is placed on the hazards related to wind, wind waves, and the propagation of deep water swell into the harbor areas. Various vessel locations/situations are considered, including moored, nesting, anchored, arriving/departing, and small boat operations. The potential problems and suggested pre-cautionary/evasive actions for various combinations of environmental threats and vessel location/situation are provided. Local indicators of environmental hazards and possible evasion techniques are summarized for various scenarios.

CAUTIONARY NOTE: In September 1985 Hurricane Gloria raked the Norfolk, VA area while several US Navy ships were anchored on the muddy bottom of Chesapeake Bay. One important fact was revealed during this incident: Most all ships frigate size and larger dragged anchor, some more than others, in winds of over 50 knots. As winds and waves increased, ships 'fell into' the wave troughs, BROADSIDE TO THE WIND and become difficult or impossible to control.

This was a rare instance in which several ships of recent design were exposed to the same storm and much effort was put into the documentation of lessons learned. Chief among these was the suggestion to evade at sea rather than remain anchored at port whenever winds of such intensity were forecast.

2. CAPTAIN'S SUMMARY

The Port of Toulon is comprised of military and commercial facilities. It is located on the south central coast of France at approximately 43°07'N 05°54'E (Figure 2-1).

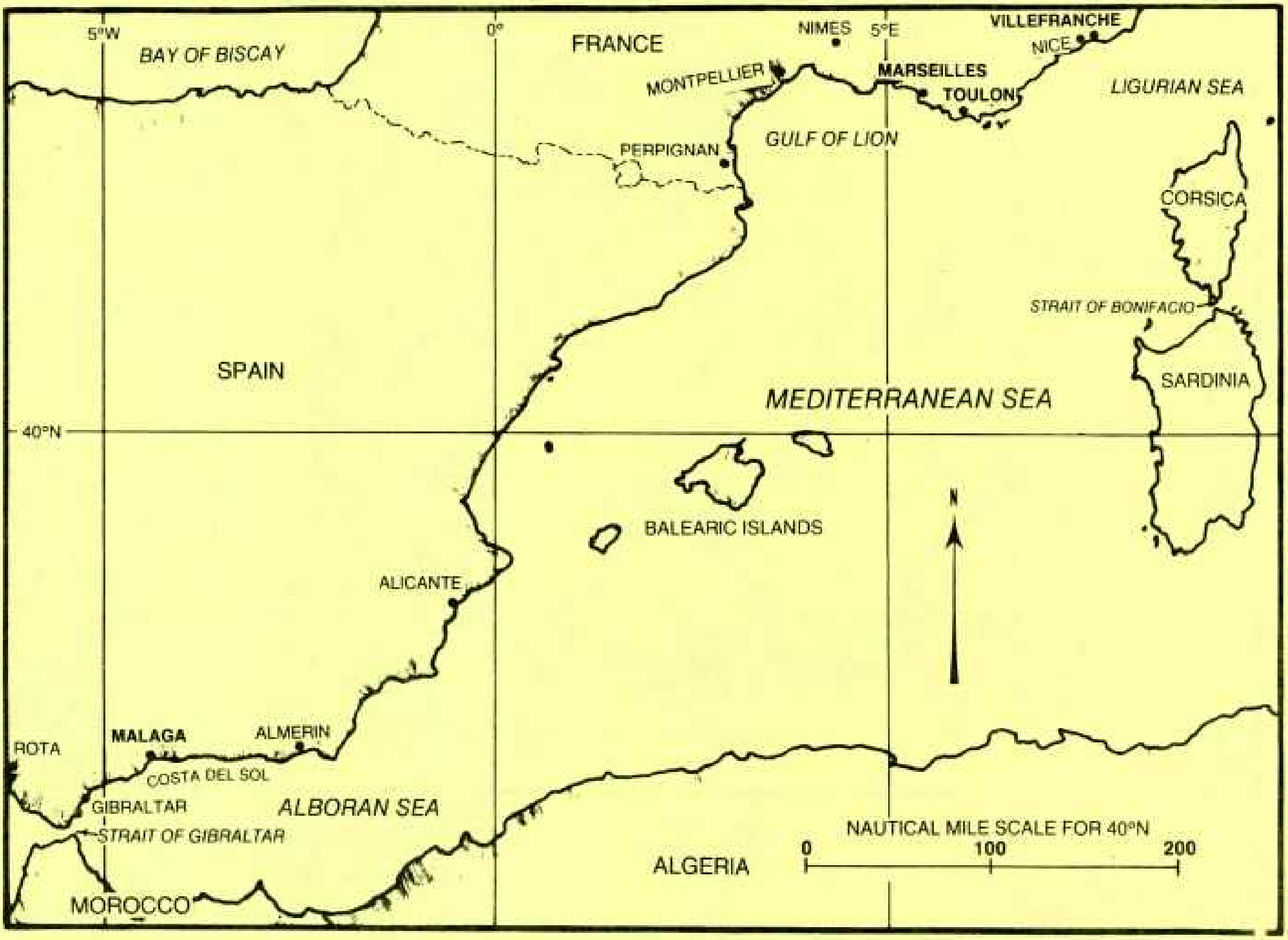

Figure 2-1. Western Mediterranean Sea.

Toulon is situated about 28 n mi east-southeast of Marseille near the eastern limit of the Gulf of Lion (Figure 2-2). The Port is well protected from winds and waves from all directions except east through southeast. The Port is considered safe during Mistral winds and leaving the harbor to evade the Mistral winds is not recommended.

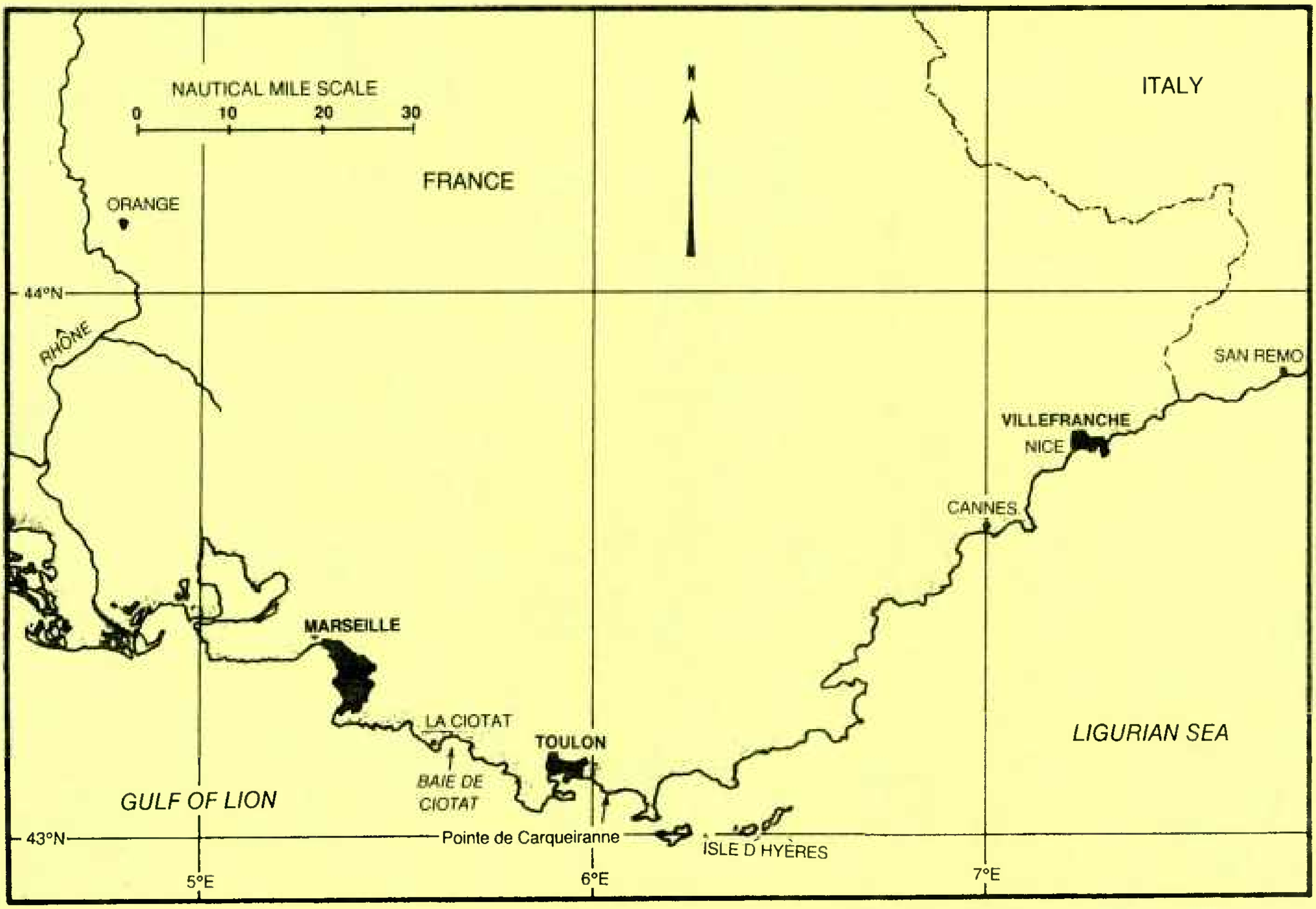

Figure 2-2. Ports of Marseille, Toulon, Villefranche.

Situated at the head of Grande Rade de Toulon (Large Roadstead of Toulon) on the north and northeastern side of a smaller body of water called Petite Rade (Small Roadstead), the harbor consists of an inner harbor and outer harbor (Figure 2-3). The outer harbor has a sand bottom with excellent holding properties while the bottom of the inner harbor is mud of unspecified holding quality. The inner harbor accommodates smaller vessels such as submarines and frigates. The outer harbor is separated from the inner harbor by a 3/4 n mi long breakwater. Larger vessels, such as aircraft carriers, anchor in the outer harbor, generally near point 2 (see Figure 2-3).

With a few exceptions, the nearby terrain is mostly low-lying, so the port is exposed to winds from nearly all directions. However, strong winds usually emanate from only two primary sectors, west to northwest and east to southeast. Because of the surrounding terrain, fetch length is extremely limited for all directions except southeast.

The anchorage is located about 1 n mi east-southeast of Stalingrad Quay (as is the Fleet Landing) and is exposed and vulnerable to strong winds and waves from east through southeast. Deep water generated swell waves to 16 ft (about 5 m) have been reported at the anchorage. Under such conditions, remaining at the anchorage is inadvisable. Marseille is more protected from easterly winds, but anchoring in the Rade de Marseille is considered hazardous during strong easterly winds.

Because the Port facilities are on the western side of the harbor, seas are fetch limited during a Mistral event. Most operations within the Port are unaffected. The maximum Mistral wind speed at Toulon is typically about 60% of the wind speed over the open sea to the south of Marseille.

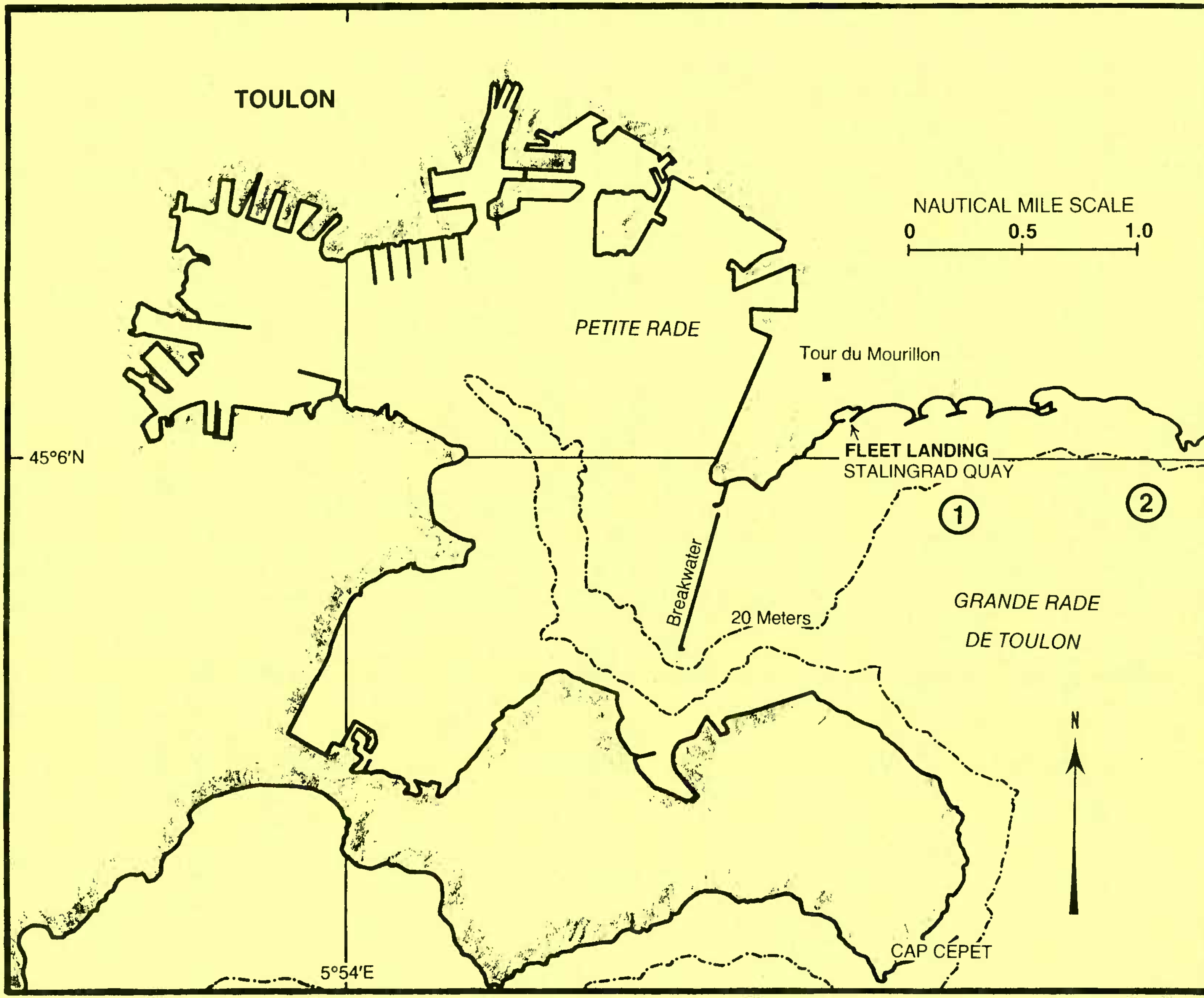

Figure 2-3. Port of Toulon.

Tides in the Port of Toulon are negligible, with a maximum rise of only 7 inches (18 cm). Currents in the approaches to the Port are weak and irregular, generally following the direction of the wind. Because winds from seaward have a greater influence on the sea, currents with a westerly set are more frequent than east-moving currents and are strongest near the coast (Hydrographer of the Navy, 1965).

Specific hazardous conditions, vessel situations, and suggested precautionary/evasion action scenarios are summarized in Table 2-1. Hazards for both inport and at anchorage are addressed.

Table 2-1. Summary of hazardous environmental conditions for the Port of Toulon, France.

HAZARDOUS CONDITION	INDICATORS OF POTENTIAL HAZARD	VESSEL LOCATION/ SITUATION AFFECTED	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS
1. Mistral wind - Strong W'ly wind. * Strongest in afternoon, weakest just after midnight. * Occurs all year, but most common and strongest in late winter/early spring, weakest in summer. * On average, Mistral blows on 146 days per year at Toulon. * Sometimes called "soufflet blanc" (white wind) because of associated clear skies.	Advance warning. * Mistral will start when the following pressure differences are achieved--highest pressure to west: * Perpignan - Marignane (Marseille), 3 mb. * Marignane (Marseille) - Nice, 3 mb. * Perpignan - Nice, 6 mb. * Wave clouds over mountains is an indicator of Mistral winds. * Mistral onset at Lus La Croix Haute provides a 2-3 hr advance warning of onset at Marseille, with onset at Toulon soon to follow. (Only 3-hourly reports available) * NW'ly winds 25 kt at Orange indicates Mistral onset at Marseille in 3-4 hr with onset at Toulon soon to follow. (Hourly reports) * Expect Mistral in about 6 hours when normal ESE afternoon sea breeze at Perpignan shifts N'ly 25-30 kt and temperature drops at least 3° F. * Exceptionally clear skies east of Toulon are an advance indicator of a Mistral. * A strong wind warning is issued from Toulon when force 6 (22-27 kt) is expected. Disseminated on VHF Channel 16, Marseille radio, and via 20 telephone lines at Weather Bureau. Warning may be in French. Duration. * Commonly lasts 3-6 days but may last 12 days without any major lulls. * When clouds come from E, the Mistral will stop and E winds will start. * When winds and fractocumulus clouds come from N instead of W to NW, the Mistral will stop within 2 hr. Extent. * When a 10 mb pressure difference exists between Toulon and Nice, the Mistral will spread E; with only 2 mb the Mistral will cease near Toulon. * The Mistral will stop if Toulon's pressure is ≥1 mb higher than that of La Ciotat (between Marseille and Toulon). * A widespread Mistral may extend far to sea; to Corsica and beyond, while a local Mistral may extend only 5-10 n mi seaward. Intensity. * Force 5 (17-21 kt) frequent, force 8 (34-40 kt) common, force 11 (56-63 kt) occasionally reached. 100+ kt expected about once each 20 years. * Air/sea temperature difference along the coast is important in determining wind speed and gustiness. The greater the difference, with the sea warmer, the stronger the wind. Associated weather. * The cold front which introduces the Mistral brings rain and sometimes violent squalls. * After initial frontal weather passes, the Mistral is usually accompanied by clear skies. * Areas in lee of high bluffs (Baie de Ciotat for example) are liable to violent squalls.	(1) Moored - inner harbor.	SHIPS IN PORT SHOULD REMAIN RATHER THAN ATTEMPT TO EVADE STORM CONDITIONS. (a) Harbor is well protected on west side--the direction from which the Mistral blows at Toulon. * Lack of fetch precludes significant waves to develop. (b) Be aware of chill factor. * Minimize personnel exposure on weather decks during cold temperatures.
		(2) Anchored - outer harbor.	(a) Past experience indicates anchorage is usable during Mistral winds approaching 50 kt. * Sand bottom in the anchorage provides excellent holding. (b) Be aware of chill factor. * Minimize personnel exposure on weather decks during cold temperatures.
		(3) Arriving/departing.	(a) Conditions in the Port of Toulon cannot be considered representative of those that will be encountered seaward of the Port entrance, and vice versa. * Wind speed and wave height will be greater at sea. Outbound vessels should be prepared for heavy weather. (b) Be aware of chill factor. * Minimize personnel exposure on weather decks during cold temperatures.
		(4) Small boats.	(a) Boating should be restricted to inner harbor and to/from anchorage and Fleet Landing. * Wind and wave conditions are less hazardous near shore. (b) Be aware of chill factor. * Minimize personnel exposure during cold temperatures. * Ensure boat crews are adequately clothed.

Table 2-1. (Continued)

HAZARDOUS CONDITION	INDICATORS OF POTENTIAL HAZARD	VESSEL LOCATION/ SITUATION AFFECTED	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS
2. E to SE winds and waves. * Most common in winter/early spring. * Winds may reach force 9 (41-47 kt). * Waves to 16 ft (5 m) may occur at anchorage. * Sometimes called "soufflet noir" (black wind) because of associated dark, cloudy skies and rain.	Advance warnings. * Watch for easterly tracking low pressure system passing south of Toulon or quasistationary low pressure center in the Gulf of Genoa. * A strong wind warning is issued from Toulon when force 6 (22-27 kt) is expected. Disseminated on VHF Channel 16, Marseille Radio, and via 20 telephone lines at Weather Bureau. Warning may be in French. Duration. * Once blowing, wind will likely continue until low pressure system passes area or moves out of Gulf of Genoa.	(1) Moored - inner harbor.	(a) Inner harbor is considered safe. * Ships in port should remain rather than attempt to evade storm conditions. * Doubling of mooring lines may be necessary. * Rain likely.
		(2) Anchored - outer harbor.	(a) Anchorage is exposed to winds and waves. * Waves to 16 ft (5 m) possible at anchorage during a strong event. * Moving to a more protected anchorage (such as Marseille) should be considered if a strong event is forecast. * Rain likely.
		(3) Arriving/departing.	(a) Arrival/departure should be scheduled to avoid high wind and wave conditions. * If committed, vessels should encounter no problems passing through entrance to inner harbor. * Rain likely.
		(4) Small boats.	(a) Small boat operations should be curtailed until wind/waves abate. * Inner harbor operations possible in lee of breakwater. * Rain likely.

For estimating shallow water wave heights, two anchorage areas have been selected (Figure 2-3). Point 2 is for the outer harbor anchorage area for vessels with drafts over 30 ft. Point 1 is about 1/2 n mi west of Point 2 and about 1/2 n mi southeast of the Fleet Landing at Stalingrad Quay.

Table 2-2 provides the height ratio and direction of shallow water waves to be expected at points 1 and 2 when the deep water wave conditions are known. The Toulon Points 1 and 2 conditions are found by entering Table 2-2 with the forecast or known deep water wave direction and period. The height is determined by multiplying the deep water height by the ratio of shallow to deep height.

Example: Use of Table 2-2 for Toulon Point 2 (Fleet Anchorage).
Deep water wave forecast as provided by a forecast center or a reported/observed deep water wave condition:
8 feet, 12 seconds, from 150°.
The expected wave condition at Toulon Point 2, as determined from Table 2-2:
6-7 feet, 12 seconds, from 155°

NOTE: Wave periods are a conservative property and remain constant when waves move from deep to shallow water, but speed, height, and steepness change.

Table 2-2. Shallow water wave directions and relative height conditions versus deep water period and direction (see Figure 2-3 for location of the points).

FORMAT: Shallow Water Direction
Wave Height Ratio: (Shallow Water/Deep Water)

TOULON POINT 1 (One-half n mi west of Point 2) 73 ft depth

Period (sec)	6	8	10	12	14	16
Deep Water Direction	Shallow Water Direction and Height Ratio					
120°	125°	120°	115°	115°	115°	110°
	.2	.2	.2	.2	.3	.2
150°	150°	140°	130°	115°	115°	115°
	.6	.5	.4	.3	.3	.3
180°	145°	140°	140°	140°	145°	145°
	.2	.2	.2	.2	.3	.3

TOULON POINT 2 (Fleet Anchorage) 106 ft depth

Period (sec)	6	8	10	12	14	16
Deep Water Direction	Shallow Water Direction and Height Ratio					
090°	125°	130°	140°	140°	140°	145°
	.2	.2	.1	.2	.3	.3
120°	125°	130°	135°	140°	155°	155°
	.3	.2	.2	.2	.2	.2
150°	150°	150°	155°	155°	150°	160°
	1.0	.9	.8	.8	.5	.8
180°	180°	170°	175°	165°	160°	165°
	.7	.5	.6	.5	.3	.6
210°	185°	180°	180°	170°	160°	170°
	.2	.2	.2	.2	.2	.3

The local wind generated wave conditions for the anchorage area identified as point 2 are given in Table 2-3. Conditions at point 1 will be similar. All heights refer to the significant wave height (average of the highest 1/3 waves). Enter the local wind speed and direction in this table to obtain the minimum duration in hours required to develop the indicated fetch limited sea height and period. The time to reach fetch limited height is based on an initial flat ocean. When starting from a pre-existing wave height, the time to fetch limited height will be shorter.

Table 2-3. Gulf of Toulon. Local wind waves for fetch limited conditions at point 2 (based on JONSWAP model).

Format: height (feet)/period (seconds)
time (hours) to reach fetch limited height

Point 2. (Fleet Anchorage)

Direction and Fetch Length (n mi) \ Local Wind Speed (kt)	18	24	30	36	42
E 3 n mi	<2 ft	<2 ft	2/3 1	2/3 1	2-3/3 1
ESE 8 n mi	<2 ft	2-3/3-4 1-2	3-4/3-4 1-2	3-4/4 1-2	4-5/4-5 1-2

Example for Point 2:

To the east-southeast (120°) there is about a 8 n mi fetch (Figure 2-2). Given an east-southeast wind at 24 kt for a period of 2 hours, the sea will have reached 2-3 feet with a period of 3-4 seconds. Wind waves will not grow beyond this condition unless the wind speed increases or the direction changes to one over a longer fetch length. If the wind waves are superimposed on deep water swell, the combined height may change in response to changing swell conditions. Wind wave directions are assumed to be the same as the wind direction.

Climatological factors of shallow water waves, as described by percent occurrence, average duration, and period of maximum energy (period at which the most energy is focused for a given height), are given in Table 2-4. See Appendix A for discussion of wave spectrum and energy distribution. These data are provided by season for two ranges of heights: greater than 3.3 ft (1 m) and greater than 6.6 ft (2 m).

Table 2-4. Shallow water climatology as determined from deep water wave propagation. Percent occurrence, average duration or persistence, and wave period of maximum energy for wave height ranges of greater than 3.3 (1 m) ft and greater than 6.6 ft (2 m) by climatological season.

TOULON POINT 1:	WINTER	SPRING	SUMMER	AUTUMN
>3.3 ft (1 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	7	2	3	11
Average Duration (hr)	13	16	13	18
Period Max Energy(sec)	9	9	8	8
>6.6 ft (2 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	1	0	<< 1	<< 1
Average Duration (hr)	11	NA	18	6
Period Max Energy(sec)	11	NA	11	11
TOULON POINT 2:	**WINTER**	**SPRING**	**SUMMER**	**AUTUMN**
>3.3 ft (1 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	6	1	3	9
Average Duration (hr)	15	6	11	14
Period Max Energy(sec)	9	10	9	9
>6.6 ft (2 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	1	0	<< 1	<< 1
Average Duration (hr)	10	NA	24	6
Period Max Energy(sec)	11	NA	11	11

Note 1: Infrequently during winter, open sea generated southerly swell with periods of 15-16 seconds reach Toulon Points 1 and 2 at heights of 4-7 feet.

Note 2: Extreme wave heights of 16 ft (5 m) have been reported at the fleet anchorage (Point 2) with gale force winds from the southeasterly sector.

SEASONAL SUMMARY OF HAZARDOUS WEATHER CONDITIONS

WINTER (November thru February):

* Mistral winds occur an average of 146 days/year and are routine in winter. Frequent 20 kt winds, 30 kt not uncommon, and 55 kt on occasion.
* Waves in harbor fetch limited so only wind sensitive operations affected.
* Harbor more affected by east to southeasterly winds. These occur an average of 86 days/year and can reach 45 kt. Waves outside harbor can be 16 ft (5 m) diminishing as they enter harbor.
* Below freezing temperatures not uncommon and, when combined with high winds, can cause hazardous wind chill.

SPRING (March thru May):

* Early spring similar to winter. Mistral events continue until late spring, then decrease in frequency and intensity.
* Wind chill still a factor with intense Mistrals.

SUMMER (June thru September):

* Mistral still occurs in summer but are infrequent and less intense.

AUTUMN (October):

* Short transition season with winter-like weather returning by the end of the month.

NOTE: For more detailed information on hazardous weather conditions see previous Summary Table in this section and Hazardous Weather Summary in Section 3.

REFERENCES

Hydrographer of the Navy, 1965: _Mediterranean Pilot_, Volume II. Published by the Hydrographer of the Navy, London, England.

3. GENERAL INFORMATION

This section is intended for Fleet meteorologists/oceanographers and staff planners. Paragraph 3.5 provides a general discussion of hazards and Table 3-5 provides a summary of vessel locations/situations, potential hazards, effects-precautionary/evasive actions, and advance indicators and other information about the potential hazards by season.

3.1 Geographic location

The Port of Toulon is comprised of military and commercial facilities. It is located on the south central coast of France at approximately 43°07'N 05°54'E (Figure 3-1).

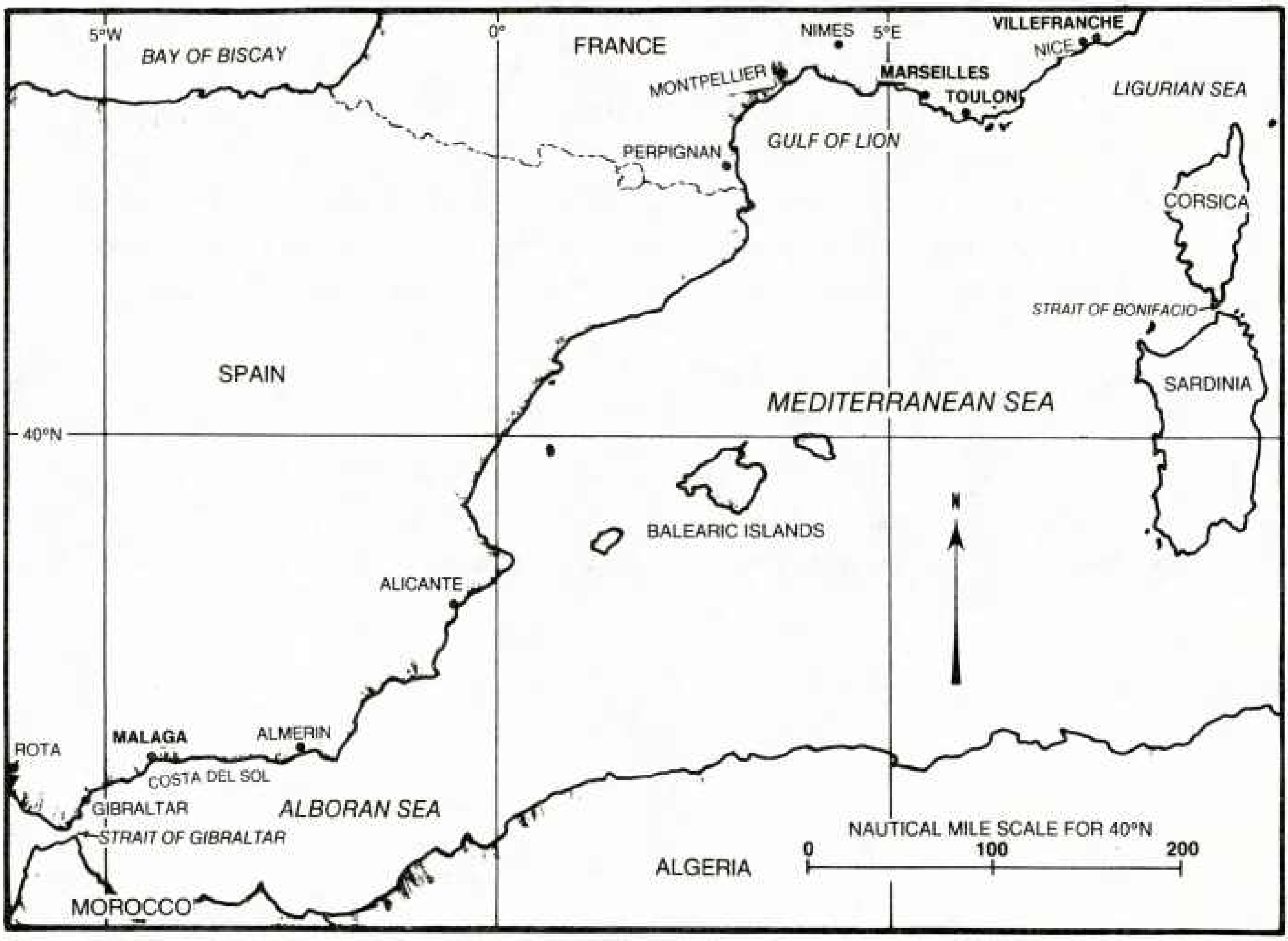

Figure 3-1. Western Mediterranean Sea.

Toulon is situated about 28 n mi east-southeast of Marseille near the eastern limit of the Gulf of Lion (Figure 3-2). The Port is well protected from winds and waves from all directions except east through southeast. The Port is considered safe during Mistral winds and leaving the harbor to evade the Mistral winds is not recommended.

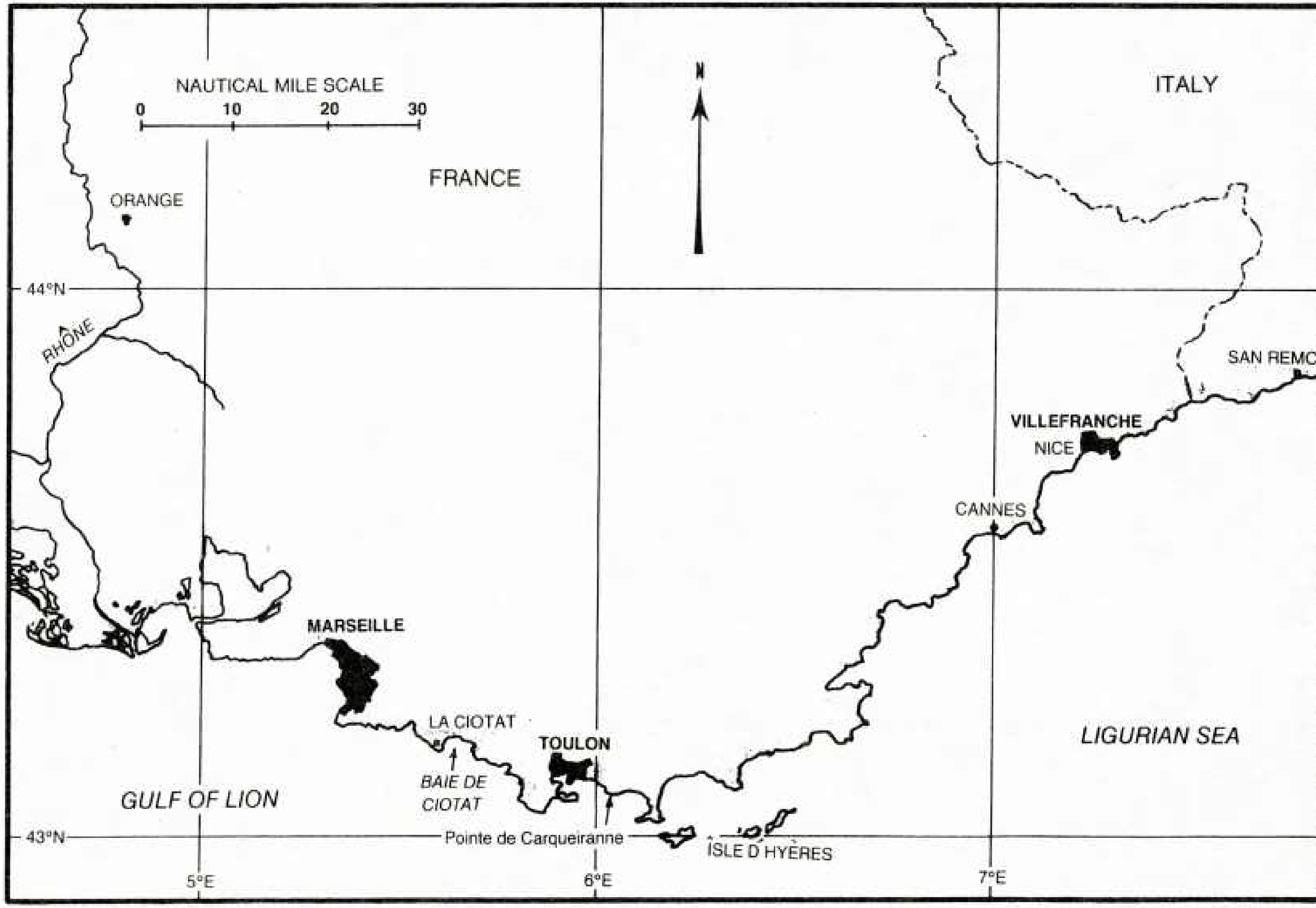

Figure 3-2. Ports of Marseille, Toulon, Villefranche.

The Port (Figure 3-3) is positioned on the north and northeastern sides of a small body of water named Petite Rade (Small Roadstead) which is situated at the head of Grande Rade de Toulon (Large Roadstead of Toulon). A 3/4 n mi long breakwater forms the western side of Grande Rade de Toulon and separates it from Petite Rade. This protects the inner harbor from open ocean waves. Landmarks identifiable from seaward are limited, but Tour du Mourillon, a seven-storied square building located in the southern part of Toulon can be easily seen (Hydrographer of the Navy, 1965). The Port of Toulon is well protected by terrain on all sides except east-southeast.

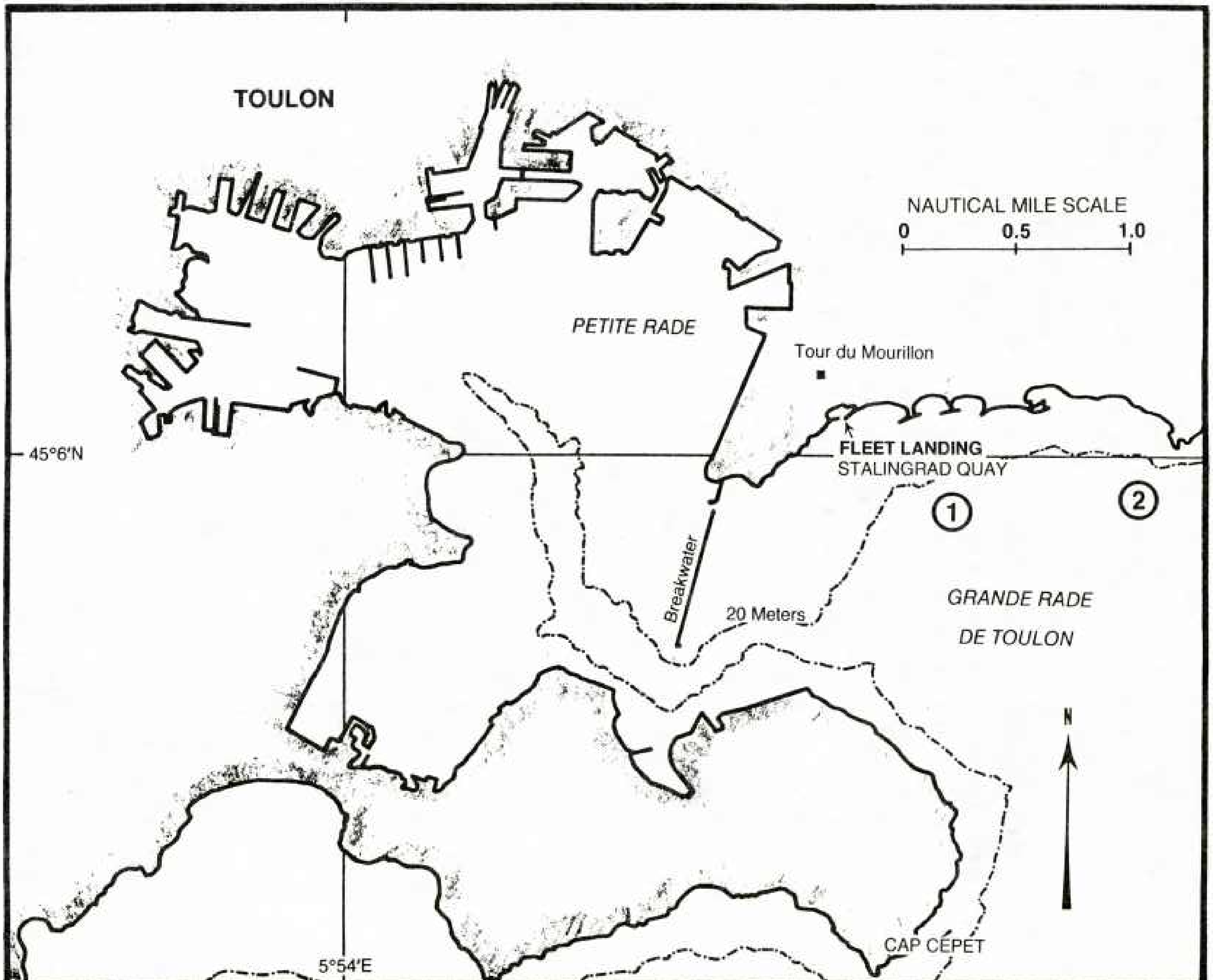

Figure 3-3. Port of Toulon.

3.2 Qualitative Evaluation of Harbor as a Haven

The inner harbor at Toulon is well protected and considered safe during storm conditions from any direction. The outer harbor is exposed to the effects of southeasterly winds and waves but is only minimally affected by westerly Mistral winds.

With a few exceptions, the nearby terrain is mostly low-lying, so the Port is exposed to winds from nearly all directions. However, strong winds usually emanate from only two primary sectors, west to northwest and east to southeast. Because of the surrounding terrain, fetch length is extremely limited for all directions except southeast.

The most significant problems at Toulon are created by east to southeasterly winds and resultant waves. Extreme wind velocities have reached force 9 (41-47 kt), with waves to 16 ft (about 5 m) at the anchorage. Offshore in the open sea, waves can reach 40 ft (12 m).

Mistral conditions, with west to northwest winds as strong as force 11 (56-63 kt), are the strongest winds that typically occur at the Port. The lack of fetch limits wave generation which allows most operations to continue within the harbor. The maximum Mistral wind speed at Toulon is typically about 60% of the wind speed over the open sea to the south of Marseille

The outer harbor has a sand bottom with excellent holding properties. The bottom of the inner harbor is mud of unspecified holding quality.

3.3 Currents and Tides

Currents in the approaches to the Port of Toulon are weak and irregular, generally following the direction of the wind. Because winds from seaward have a greater influence on the sea, currents with a westerly set are more frequent than east moving currents and are strongest near the coast (Hydrographer of the Navy, 1965).

Tides are insignificant at Toulon, with a maximum rise of only 7 inches (18 cm).

3.4 Visibility

Discussions with local harbor personnel indicate that fog is at a maximum during early mornings in the warm season. Reduced visibility is common after Mistral-induced upwelling occurs in the coastal waters. Even then, prevailing visibility is still near 5 mi so port operations are not adversely affected. Visibility has been severely restricted only once or twice in 18 years.

3.5 Hazardous Conditions

The location of Toulon on the south coast of France near the Rhône and Durance valleys exposes the Port to strong Mistral winds, while the configuration of Grande Rade de Toulon exposes that portion of the Port to southeasterly winds and waves.

Although uncommon, storms having tropical cyclone characteristics with fully developed eyes have been observed on at least three occasions in the Mediterranean Basin: 23-26 September 1969, 22-28 January 1982, and 26-30 September 1983. On the latter occasion the storm moved northwest from the Gulf of Gabes (on the southeast coast of Tunisia), through the Straits of Sicily, along the east coast of Sardinia, and into the Gulf of Genoa. Winds of 100 kt were observed near the eye while Cagliari, Sardinia reported winds of 60 kt. While the probability of such a storm striking Toulon is very slight, the meteorologist must be aware of the possibility.

A seasonal summary of various known environmental hazards that may be encountered in the Port of Toulon follows.

A. Winter (November through February)

The winter season at Toulon is marked by cool temperatures, precipitation, and periods of strong winds. Although Toulon is near the eastern limit of that portion of the southern coast of France normally affected by the Mistral, the Port experiences Mistral winds on an average of 146 days per year. They are a routine wintertime occurrence. The following definition of a Mistral is attributed to A. Orieux and is taken from Digest of Selected Weather Problems of the Mediterranean (Reiter, 1971). Orieux defines the Mistral (at Marignane (Marseille)), station number 07650, as "a wind with a direction between 280° and 360° and with a speed of 10 kt (5 m/s) or more. Both criteria have to be met for at least 6 consecutive hours. A Mistral period is considered as terminated if either the speed criterion, or the direction criterion, or both are violated for a time interval of 6 hours or more."

According to Hydrographer of the Navy (1965), there is no generally agreed lower limit to the speed of a wind which may be described as a Mistral, but force 5 (17-21 kt) is frequently experienced, gale force (34-40 kt) is not uncommon, and force 11 (56-63 kt) is occasionally reached. Gradually increasing in intensity and frequency of occurrence, Mistral events are strongest and most frequent during February to April, after which there is a gradual decrease. Records for Toulon for the years 1951-1980 show a maximum velocity of 105 kt (54 m/s) was attained in January 1951. Generally, the effect of the Mistral on port operations is minimal. A diurnal variation in the intensity of the Mistral results in maximum wind strengths occurring during the afternoon at Toulon and other coastal stations (Brody and Nestor, 1980). NOTE: This is contrary to what occurs over the sea where maximum winds tend to occur at night.

The air-sea temperature difference is an important factor in Mistral strength. Winds are stronger when the air is much colder than the coastal water temperature. Winds will decrease after upwelling (caused

by the offshore component of the wind) brings cooler water to the surface. The Mistral is sometimes referred to as "soufflet blanc" (white wind) because it is usually accompanied by clear skies.

East to southeasterly winds are a greater problem to the Port. Occurring about 86 days per year at Toulon, they are most common during winter and early spring. Sometimes called "soufflet noir" (black wind) because they are associated with dark, cloudy skies and rain, the winds reach force 9 (41-47 kt) and can be accompanied by 16 ft (about 5 m) waves at the anchorage. Winds from the southeast are usually caused by an easterly tracking low pressure center passing south of Toulon, or with a quasistationary low in the Gulf of Genoa. In the latter case, the configuration of the landmass east of Toulon (i.e. mountains, cliffs along the coast) induces an anticyclonic curvature to the circulation on the west side of the low, creating an easterly wind which enters the Port. The wind is usually stronger than the pressure gradient indicates. Conditions in the anchorage might dictate leaving the Port for more protected waters (such as Marseille), but ships in the inner harbor should remain rather than attempt to evade.

A wind warning is issued for Toulon when force 6 (22-27 kt) or greater winds are occurring or forecast. Such warnings are disseminated via VHF Channel 16, Marseille Radio, and over 20 telephone lines at the Weather Bureau.

The rainy season at Toulon lasts from about 15 January through 15 March, with most of the precipitation occurring during east to southeasterly flow. During northeast to southeast winds, a Foehn effect keeps Marseille dry while Toulon will get rain. When clouds approach from the southwest, rain will start first at Marseille, but reach Toulon in 3 hours or so. The Mistral is usually accompanied by clear skies, but the cold front which precedes the Mistral may bring rain (or possibly snow) and violent squalls. Where there is high ground near the coast, such as at Baie de Ciotat between

Toulon and Marseille, violent squalls may be felt in the lee.

Winter temperatures can reach into the low 30's (Fahrenheit) and colder. When the low temperatures are combined with wind, the resultant wind chill can be quite cold, and personnel working in exposed locations must take appropriate precautions. Table 3-1 can be used to determine wind chill for various temperature and wind combinations.

Table 3-1. Wind Chill. The cooling power of the wind expressed as "Equivalent Chill Temperature" (adapted from Kotsch, 1983).

Wind Speed		Cooling Power of Wind expressed as "Equivalent Chill Temperature"								
Knots	MPH	Temperature (°F)								
Calm	Calm	40	35	30	25	20	15	10	5	0
		Equivalent Chill Temperature								
3-6	5	35	30	25	20	15	10	5	0	-5
7-10	10	30	20	15	10	5	0	-10	-15	-20
11-15	15	25	15	10	0	-5	-10	-20	-25	-30
16-19	20	20	10	5	0	-10	-15	-25	-30	-35
20-23	25	15	10	0	-5	-15	-20	-30	-35	-45
24-28	30	10	5	0	-10	-20	-25	-30	-40	-50
29-32	35	10	5	-5	-10	-20	-30	-35	-40	-50
33-36	40	10	0	-5	-15	-20	-30	-35	-45	-55

B. Spring (March through May

As is typical for other ports in the northern Mediterranean basin, the spring season brings periods of stormy winter-type weather that alternates with false starts of summer-type weather (Brody and Nestor, 1980). Mistral events continue through the season, alternating with east to southeast winds associated with transient low pressure systems passing south of Toulon or located in the Gulf of Genoa. Strong east to southeast winds are uncommon by the end of the season.

Precipitation is common through mid-March, and is usually associated with transient extratropical storm systems or the cold front which precedes the Mistral. Precipitation still occurs after mid-March, but the frequency of occurrence and monthly totals gradually decrease through May.

Sea breezes become evident on warm days late in the season. Seldom exceeding force 2 (4-6 kt), the sea breeze direction usually "follows the sun," changing from easterly in the morning to westerly in the afternoon as surrounding hillsides are warmed by the sun.

Temperatures moderate gradually throughout the season but wind chill remains a factor during Mistral winds until late in the season.

C. Summer (June through September)

The summer season is one of warm temperatures and relatively dry and settled weather along the south coast of France. Although cold outbreaks continue to bring Mistral conditions to Toulon, they are less strong and not as frequent as during winter and spring.

The extratropical storm track has moved well north of the Mediterranean basin by summer, so extratropical cyclones and associated wind and weather are not common. Daily sea breezes reaching force 2 (4-6 kt) are the rule, with the direction following the sun as the hillsides of the terrain surrounding the Port are heated.

D. Autumn (October)

The transitional season of autumn is brief, usually lasting only for the month of October, and is characterized by an abrupt change to winter-type weather (Brody and Nestor, 1980).

Mistral frequency starts to increase, with strong events uncommon but possible. East to southeasterly winds, accompanied by precipitation, begin to occur more frequently as the extratropical storm track moves southward to the northern Mediterranean region.

Temperatures decrease significantly by the end of the month, but wind chill is not usually a problem until winter.

3.6 Harbor Protection

As discussed below, the inner harbor is not significantly affected by wind and waves, but the outer harbor, including the anchorage, is exposed to some conditions.

3.6.1 Wind and Weather

The inner harbor at Toulon is considered to be well protected on all sides except the east-southeast. However, during periods of strong east to southeast winds, ships in port should remain rather than attempt to evade storm conditions. Vessels experience minimal problems passing through the entrance to the inner harbor in strong southeasterly winds.

The outer harbor and anchorage is not as well protected as the inner harbor, and the forecast of strong winds from east to southeast is cause to consider moving to a more protected anchorage. Marseille is more sheltered from east and southeast winds and also tends to have better weather during such flow patterns.

Mistral winds do not materially affect harbor operations. Even in a strong Mistral, with winds approaching 50 kt, past experience has shown that an aircraft carrier found safe anchorage about 3/4 n mi southeast of Stalingrad Quay. Small boats were able to make runs to/from the Fleet Landing and the anchored carrier with no difficulty during one such experience.

3.6.2 Waves

Due to lack of fetch, Mistral winds do not produce significant waves in Toulon Harbor, with waves at the anchorage limited to about 3 ft (1 m). But east to

southeast winds can generate large waves at the anchorage, with reported events of 16 ft (about 5 m) waves during winds of force 9 (41-47 kt). Some of the wave energy will refract around the breakwater and into the inner harbor, but the resultant waves should not cause serious problems for vessels moored alongside the inner harbor piers.

Table 3-2 provides the shallow water wave conditions at the two designated points when deep water swell enters the harbor.

Example: Use of Table 3-2.

For a deep water wave condition of:

8 feet, 12 seconds, from 150°

The approximate shallow water wave conditions are:

Point 1: 2-3 feet, 12 seconds, from 115°
Point 2: 6-7 feet, 12 seconds, from 155°

Table 3-2. Shallow water wave directions and relative height conditions versus deep water period and direction (see Figure 3-3 for location of the points).

FORMAT: Shallow Water Direction
Wave Height Ratio: (Shallow Water/Deep Water)

TOULON POINT 1 (One-half n mi west of Point 2) 73 ft depth

Period (sec)	6	8	10	12	14	16
Deep Water Direction	Shallow Water Direction and Height Ratio					
120°	125°	120°	115°	115°	115°	110°
	.2	.2	.2	.2	.3	.2
150°	150°	140°	130°	115°	115°	115°
	.6	.5	.4	.3	.3	.3
180°	145°	140°	140°	140°	145°	145°
	.2	.2	.2	.2	.3	.3

TOULON POINT 2 (Fleet Anchorage): 106 ft depth

Period (sec)	6	8	10	12	14	16
Deep Water Direction	Shallow Water Direction and Height Ratio					
090°	125°	130°	140°	140°	140°	145°
	.2	.2	.1	.2	.3	.3
120°	125°	130°	135°	140°	155°	155°
	.3	.2	.2	.2	.2	.2
150°	150°	150°	155°	155°	150°	160°
	1.0	.9	.8	.8	.5	.8
180°	180°	170°	175°	165°	160°	165°
	.7	.5	.6	.5	.4	.6
210°	185°	180°	180°	170°	160°	170°
	.2	.2	.2	.2	.2	.3

Situation specific shallow water wave conditions resulting from deep water wave propagation are given in Table 3-2 while the seasonal climatology of wave conditions in the harbor resulting from the propagation of deep water waves into the harbor are given in Table 3-3. If the actual or forecast deep water wave conditions are known, the expected conditions at the two specified harbor areas can be determined from Table 3-2. The mean duration of the condition, based on the shallow water wave heights, can be obtained from Table 3-3.

Example: Use of Tables 3-2 and 3-3.

The forecast for wave conditions tomorrow (winter case) outside the harbor are:

8 feet, 14 seconds, from 180°

Expected shallow water conditions and duration:

	Point 1	Point 2
height	2-3 feet	3-4 feet
period	14 seconds	14 seconds
direction	from 145°	from 160°
duration	NA for <3.3 ft	15 hours

Interpretation of the information from Tables 3-2 and 3-3 provide guidance on the local wave conditions expected tomorrow at the various harbor points. The duration values are mean values for the specified height range and season. Knowledge of the current synoptic pattern and forecast/expected duration should be used when available.

Possible applications to small boat operations are; selection of the mother ships anchorage point and/or areas of small boat work. The condition duration information provides insight as to how long before a change can be expected. The local wave direction information could be of use in selecting anchorage configuration and related small boat operations, including tending activities.

Table 3-3. Shallow water climatology as determined from deep water wave propagation. Percent occurrence, average duration or persistence, and wave period of maximum energy for wave height ranges of greater than 3.3 ft (1 m) and greater than 6.6 ft (2 m) by climatological season.

TOULON POINT 1:	WINTER	SPRING	SUMMER	AUTUMN
>3.3 ft (1 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	7	2	3	11
Average Duration (hr)	13	16	13	18
Period Max Energy(sec)	9	9	8	8
>6.6 ft (2 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	1	0	<< 1	<< 1
Average Duration (hr)	11	NA	18	6
Period Max Energy(sec)	11	NA	11	11
TOULON POINT 2:	**WINTER**	**SPRING**	**SUMMER**	**AUTUMN**
>3.3 ft (1 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	6	< 1	3	9
Average Duration (hr)	15	6	11	14
Period Max Energy(sec)	9	10	9	9
>6.6 ft (2 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	1	0	<< 1	<< 1
Average Duration (hr)	10	NA	24	6
Period Max Energy(sec)	11	NA	11	11

Note 1: Infrequently during winter, open sea generated southerly swell with periods of 16 seconds reach Toulon Points 1 and 2 at heights of 4 to 7 feet.

Note 2: Extreme wave heights of 16 ft (5 m) have been reported at the fleet anchorage (Point 2) with gale force winds from the southeasterly sector.

Local wind wave conditions are provided in Table 3-4 for Toulon point 2. Conditions at point 1 will be similar. The fetch lengths are specifically for point 2. The time to reach the fetch limited height assumes an initial flat ocean. With a pre-existing wave height, the times are shorter.

Table 3-4. Toulon Point 2. Local wind waves for fetch limited conditions at Point 2 (based on JONSWAP model).

Point 2. (Fleet Anchorage)

Direction and Fetch Length (n mi) \ Local Wind Speed (kt)	18	24	30	36	42
E 3 n mi	<2 ft	<2 ft	2/3 1	2/3 1	2-3/3 1
ESE 8 n mi	< 2ft	2-3/3-4 1-2	3-4/3-4 1-2	3-4/4 1-2	4-5/4-5 1-2

Example: Small boat wave forecasts for the fleet anchorage to fleet landing run (based on the assumption that swell is not a limiting condition).

Forecast for Tomorrow:

Time	Wind (Forecast)	Waves (Table 3-4)
prior to 0700 LST	light and variable	< 1 ft
0700 to 1200	ESE 8-10 kt	< 2 ft
1200 to 1800	ESE 22-26 kt	building to 2-3 ft at 3-4 sec by 1400

Interpretation: Assuming that the limiting factor is waves greater than 3 feet, small boat operations would become marginal by 1300.

Note: In this situation with the open fetch to the southeast there would likely be a significant swell propagating into the area and the combined wind wave and swell could result in significantly higher wave heights than the wind waves alone.

Combined wave heights are computed by finding the square root of the sum of the squares of the wind wave and swell heights. For example, if the wind waves were 3 ft and the swell 8 ft the combined height would be about 8.5 ft.

$$\sqrt{3^2 + 8^2} = \sqrt{9 + 64} = \sqrt{73} \approx 8.5$$

Note that the increase in combined height over the larger of the two is relatively small, 8 to 8.5 ft. Even if the two wave types were of equal height the combined heights are only 1.4 times the individual heights. In cases where one or the other heights are twice that of the other, the combined height will only increase over the larger of the two by 1.12 times (10 ft swell and 5 ft wind wave combined results in 11.2 ft height).

3.6.3 Wave Data Uses and Considerations

In general, local wind waves build up quite rapidly and also decrease rapidly when winds subside. The period and therefore length of wind waves is generally short relative to the period and length of swell waves propagated into the harbor (see Appendix A). The shorter period and length result in wind waves being characterized by choppy conditions. When wind waves are superimposed on deep water waves propagated into shallow water, the combined wave action can become quite complex and confused. Under such conditions, when more than one source of waves is influencing a location, tending or joint operations can be hazardous even if the individual wave train heights are not significantly high. Vessels of various lengths respond with different motions to the diverse wave lengths present. The information on wave periods, provided in the previous tables, should be considered when forecasts are made for joint operations of various length vessels.

3.7 Protective/Mitigating Measures

3.7.1 Sortie/Remain in Port

Due to the protection provided by the surrounding countryside and the breakwater, the inner harbor is considered a safe haven. Sorties are not required to evade commonly encountered high winds or waves. However, leaving the Port and evading the storm at sea would be the recommended course of action in the extremely rare event when a tropical cyclone is forecast to impact the Toulon harbor.

3.7.2 Moving to New Anchorage

The anchorage located southeast of Stalingrad Quay is usable in Mistral conditions and moving to a new anchorage is not recommended. As discussed in section 3.6.1 previously, an aircraft carrier was able to anchor without difficulty about 3/4 n mi southeast of the quay in winds approaching 50 kt. Small boats were able to make runs to the Fleet Landing at Stalingrad Quay during the Mistral because wind speeds are typically lower near the shore and the fetch is too short to allow waves of significant height to develop. Local reports indicate that much stronger winds are normally being experienced 1-3 n mi offshore.

East to southeast winds pose a far greater hazard to ships at the anchorage than does the Mistral. As stated in section 3.6.2, waves to 16 ft (about 5 m) are possible at the anchorage in a strong event. If strong east to southeast winds are forecast, moving to a more protected anchorage should be considered. Marseille is more sheltered and might be considered the better anchorage under such conditions. However, anchoring in Rade de Marseille is not recommended because it does not provide adequate protection from strong east winds in winter nor during frequent changes of wind conditions (Hydrographer of the Navy, 1965).

3.7.3 Scheduling

While the inner harbor and anchorage are considered safe during Mistral conditions, inbound and outbound vessels should schedule their arrival or departure to avoid the strongest winds. Consequently, an early morning evolution is recommended since the Mistral winds are strongest at coastal stations during the afternoon. No such diurnal variation has been reported for east to southeast winds.

3.8 Indicators of Hazardous Weather Conditions

The Port of Toulon is relatively well protected from the effects of severe weather, but since conditions can change rapidly, it is advisable to be aware of potential changes. The following guidelines have been extracted from various sources, including on-site interviews, and are intended to provide the insight necessary to enable the meteorologist to better understand the various phenomena that affect the Port of Toulon. Since the Mistral is more extensively documented than other phenomena affecting Toulon, much of the following addresses the Mistral. Other sources are used, but the bulk of the guideline content is taken from Brody and Nestor (1980). While some of the Mistral guidelines do not apply directly to Toulon, they are included because of the possibility that the Mistral winds will spread eastward to Toulon once they are established in the more western portions of the Gulf of Lion.

3.8.1 Mistral

1. Causes

The Mistral is the result of a combination of the following factors:

(a) The basic circulation that creates a pressure gradient from west to east along the coast of

southern France. This pressure gradient is normally associated with Genoa cyclogenesis.

(b) A fall wind effect caused by cold air associated with the Mistral moving downslope as it approaches the southern coast of France and thus increasing the wind speed.

(c) A jet-effect wind increase caused by the orographic configuration of the coastline. This phenomenon is observed at the entrance to major mountain gaps such as the Carcassone Gap, Rhône Valley, and Durance Valley. It is also observed in the Strait of Bonifacio between Corsica and Sardinia.

(d) A wind increase over the open water resulting from the reduction in the braking effect of surface friction (as compared to the braking effect over land).

Mistrals are observed in association with three particular upper level (500 mb) large-scale flow patterns. These flow patterns are classified as types A, B, and C by the British Air Ministry (1962).

Type A. A blocking ridge in the eastern Atlantic and a long-wave trough over Europe produces a strong northwesterly flow over western France. This is a meridional flow situation.

Type B. A blocking ridge extends northeastward from the eastern Atlantic over northern Europe and a low pressure belt covers the Mediterranean. Meridional flow predominates.

Type C. A series of depressions dominates the European mid-latitudes, and westerly winds prevail over the Mediterranean. This is a zonal-flow situation.

2. Onset

The following guidelines for forecasting the onset of a Mistral have been extracted from Brody and Nestor (1980).

In association with a Type A large-scale flow pattern:

(a) Forecast the start of a Mistral within 48 hr when a surface frontal trough is located just south of Iceland and is backed by an extremely strong surge of cold air to the east of Greenland. (Note: The long-wave ridge axis is west of Iceland. This rule is biased toward established rather than developing patterns).

(b) Forecast the start of a Mistral within 24 hr when the frontal and 500 mb short-wave troughs extend across southern (or southeastern) England and the Bay of Biscay, and the short-wave ridge is located over Spain and France. (Note: The long-wave ridge axis is west of Iceland. This rule is biased toward established rather than developing patterns).

(c) A Mistral will occur if the 500 mb winds over England or Ireland are northwesterly 50 kt or more.

(d) A Mistral will start when the 500 mb short-wave arrives over Perpignan.

A Mistral is likely to occur with a Type A situation when: (1) the long wave trough is over or just past the south coast of France; and (2) a northwesterly (west through north-northeast) current with maximum speed of at least 50 kt at 500 mb is oriented so that it points toward the Gulf of Lion.

In association with a Type B large-scale flow pattern, forecast the start of a Mistral in 24 hr when: (1) the 500 mb trough moves over or just south of the south coast of France; and (2) the associated surface low appears in or near the Gulf of Genoa.

In association with a Type C large-scale flow pattern:

(a) Forecast the start of a Mistral within 48 hr when (1) a surface frontal trough and upper short-wave trough are 24° of longitude to the west of the Gulf of Lion, (2) the short-wave ridge is 12° west, and (3) both are progressing at a speed of 12° per day. (Note: The "rule of thumb" in this case is that these short-wave ridges and troughs replace each other in 24

hr, i.e., there is a tendency toward a 48 hr periodicity of frontal systems moving into France as long as the high-index circulation is maintained. Mistrals in this situation must be short-lived.)

(b) In association with a Type C large-scale flow pattern, forecast the start of a Mistral within 24 hr when the surface and 500 mb short-wave troughs extend from the Irish Sea southward over Portugal, and the short-wave ridge is over southern France. (Note: The pattern is poorly defined in this high-index situation.)

(c) In association with a Type C large-scale flow pattern, a Mistral will occur if a deepening 500 mb trough moves over the south coast of France and is followed by a 500 mb ridge building at about the longitude of Ireland and Spain.

(d) In association with a Type C large-scale flow pattern, a Mistral will start when a northwesterly jet stream arrives over the Bay of Biscay.

The synoptic situations for the following guidelines vary.

(a) If a cutoff low as seen at 500 mb forms over northeast France and produces a northwesterly flow at 500 mb over the south coast, a Mistral may occur even though 500 mb wind speeds do not reach 50 kt and the jet axis is located far to the west and south.

(b) A Mistral generally sets in when the surface front or trough passes Perpignan, or the 500 mb trough passes Bordeaux. (Note: These two events are expected to occur nearly simultaneously.)

(c) Genoa lows occur almost simultaneously with the onset of the Mistral in the Gulf of Lion, and they invariably form when conditions are right for a Mistral to occur.

(d) If a 500 mb trough extends from central Europe southward over North Africa, a surface low from Algeria may propagate northward, intensify in the Gulf of Genoa, and initiate a Mistral.

(e) The Mistral will start when one of three surface pressure differences is achieved: Perpignan-Marignane (Marseille), 3 mb; Marignane-Nice, 3 mb; or Perpignan-Nice, 6 mb. A difference usually occurs from 0 to 24 hr after a closed Genoa low appears, but it occasionally occurs earlier.

(f) Wave clouds, such as observed on high-resolution Defense Meteorological Satellite Program (DMSP) satellite imagery, are observed over the Massif Central of southern France approximately 6 hr before the start of a Mistral.

(g) Lus La Croix Haute (station 07587) will provide a 2-3 hr advance notice of Mistral onset. This wind speed report will closely approximate the wind speed in the Gulf. (Note: Usefulness of this station is limited by the fact it only reports every 3 hr.)

(h) Orange (station 07579) gives a good 3-4 hr warning of a gale force Mistral when winds at this station increase to 25 kt northwesterly. Hourly reports are available from this station.

(i) By observing changes in the normally strong afternoon sea breeze direction (east-south-easterly) at Perpignan (station 07747), it is possible to forecast the beginning of a Mistral in the Gulf of Lion. If, at this station, the wind shifts northerly with speeds increasing to 25-30 kt and the temperature drops at least 3°F, a strong Mistral (40-50 kt) will be blowing in the Gulf of Lion within 6 hr.

(j) The probability of Mistral occurrence is greatest (correlation coefficient, r = 0.62) if the 500 mb wind direction at Bordeaux (station 07510) is 330°-340° to 040°-050°, when the 500 mb trough reaches Nimes (station 07645). The probability decreases rapidly as direction changes either to the west or east from the 330°-050° band.

(k) The probability of Mistral occurrence with a blocking pattern is greatest (r = 0.30) if, at the time the trough reaches Nimes, the Nimes height deviation from normal is about +200 m. For

progressive systems, the probability increases from r = 0.26 for deviations of +75 m to r = 0.98 for deviations of -350 m.

(l) The probability of Mistral occurrence is greatest when the 850 mb wind direction over Nimes is from 350°. It decreases with winds east or west of 350°, reaching near zero for winds from 240° and 090°.

(m) The probability of Mistral occurrence increases with the north component of the 850° mb wind at Nimes, reaching r = 0.93 for 50 kt.

3. Intensity

Although gusts of 70 kt in strong Mistral are experienced, the proportion of days when Mistral reaches gale force on the coast is small. At Perpignan and Marseille the number of days when Mistral reaches gale force is of the order of 10 to 15 in a year, (Hydrographer of the Navy, 1965).

The following guidelines are extracted from Brody and Nestor (1980).

(a) Strongest winds associated with a Mistral do not occur until after the passage of the upper-level (500 mb) trough. This occurs well after the surface cold frontal passage.

(b) Forecast Mistral winds to increase during a Type A large-scale flow pattern aloft 24 hr after a new cold front or minor trough appears in the northwest current over southern England, and the maximum speed at 500 mb in the current increases at least 10 kt while the inflection point (IP) retrogrades or remains stationary; or with the passage of the new cold front or minor trough.

(c) Satellite observations indicating a strong Mistral will exhibit the following features: cloudy over France and clear over the water area south of the 1,000 ft water depth contour; clear over the Gulf of Lion but a cloud mass, parallel to the coast, lying 75-150 n mi offshore; wispy cloud streaks extending from 315° to 350° into offshore clouds. See NTAG Vol. 2 pg

2D-8 (NEPRF, 1977) and NTAG Vol. 3 page 2B-17 (NEPRF, 1980) for satellite case studies of Mistral events.

(d) Wave clouds extending from Sardinia to Tunisia, viewed on satellite imagery, are generally associated with gale force Mistral situations.

(e) Maximum Mistral winds occur when the surface isobars are at an angle of 30° to the valleys of either the Garonne, the Rhône or the Durance with low pressure to the southeast.

(f) Use the information below to estimate wind speed associated with a Mistral in the Gulf of Lion.

Pressure Difference (mb)	Perpignan* (station 07747) and Nice (station 07690)	Perpignan* and Marignane (station 07650)	Marignane** and Nice
3		30-35 kt	30-35 kt
4		40	40
5		45-50	45-50
6	30-35 kt		
8	40		
10	45-50		

* Highest pressure at Perpignan
** Highest pressure at Marignane

(g) A good indication of the intensity of a Mistral in the Gulf of Lion can be obtained by adding 10 kt to the wind speed reported by either Montpellier (station 07643) or Istres (station 07647).

(h) If the 500 mb winds reported at either Bordeaux (station 07510) or Brest (station 07110) are northwesterly 65 kt or greater, storm warnings instead of gale warnings are indicated for the Gulf of Lion.

(i) Wind speeds over open water during a Mistral will be approximately double those measured at Perpignan or Marignane (Marseille) except in storm conditions, when the ratio will be lower.

According to local personnel, the air/sea temperature difference along the coast is important in determining wind speed and gustiness. The greater the

difference, the stronger and more gusty the wind. When upwelling caused by the offshore component of the Mistral winds occurs, wind speeds will decrease due to the decreased temperature difference.

4. <u>Duration</u>

The Mistral may last for only a few hours, but on occasions for as many as 12 days without any important lulls. The most frequent length of an event is about 3 1/2 days (Meteorological Office, 1962).

Discussions with local personnel indicate that when clouds come from the east the Mistral is weakening and east winds will soon start. When strong winds and fractocumulus clouds come from the north instead of northwest, the Mistral will stop within 2 hours.

The following guidelines are taken from Brody and Nestor (1980).

In association with a Type A large-scale flow pattern (described above under Mistral causes), surface winds usually decrease, i.e., the Mistral ceases, when the jet axis moves eastward and an anticyclonic regime is established. This rule reflects the control on the surface pattern that is exercised by the upper air pattern.

The Mistral will cease when the cyclonic regime at the surface gives way to an anticyclonic regime. Indications of this change are:

(a) The surface wind direction becomes north to northeast.

(b) The 500 mb ridge begins to move over the area.

(c) High pressure at the surface begins to move into the western basin of the Mediterranean.

(d) There is a change that reduces the pressure difference between France and the western basin.

Cold advection on the western flank of a blocking ridge over the eastern Atlantic may herald the breakdown of the long-wave pattern and hence, of the Mistral. This rule applies to Types A and B large-scale flow patterns

where breakdown of the ridge, rather than eastward movement, results in cessation of the Mistral.

5. Extent

The Mistral may occur as a "local Mistral" or a "widespread Mistral" depending on the conditions which initiate the wind. The geography of the lower reaches of the Rhône Valley, including the Rhône delta, Marseille and to some extent Toulon, is conducive to the formation of a local Mistral when conditions for a widespread Mistral may not be present. When a local Mistral is blowing, only the Rhône delta (and possibly Toulon) may be affected. In such cases, the wind may extend only 5 or 10 n mi to seaward.

On other occasions, however, the Mistral may be widespread and may affect the whole of the Gulf of Lion and may extend as far as the African coast and Malta. At such times it is common for the wind to be stronger in the Rhône delta-Marseille (and Toulon) region than elsewhere. Eastward from Iles d'Hyères there is rapid decrease in the frequency and in the average force of the Mistral. It blows at times all along this coast but because of its reduced frequency and intensity it is not as strong here as around the Rhône delta, and the general climate of the French Riviera benefits from being sheltered from the more intense form of Mistral which is experienced farther west. Often, light easterlies are reported from Nice when strong northwesterlies are blowing at Marseille (Hydrographer of the Navy, 1965).

Alongshore pressure gradient is important in predicting Mistral intensity. When the difference is small the Mistral will stop. When a 10 mb difference exists between Toulon and Nice, the Mistral will spread eastward. With only a 2 mb difference between Marseille and Toulon, the Mistral will cease near Toulon. If surface pressure in Toulon is 1 mb or more greater than that of La Ciotat (a coastal station between Toulon and Marseille), the Mistral will stop.

The eastern boundary of the Mistral extends downwind from the western edge of the Alps through San Remo, Italy (Brody and Nestor, 1980).

6. Frequency

On average, Toulon will experience Mistral/westerly winds on 146 days per year (40%).

7. Associated Weather

When fully established, the Mistral is usually accompanied by clear skies. However, rain (or in winter, rain and/or snow) and violent squalls commonly accompany the cold front which precedes the Mistral. Where there is high ground near the coast, such as Baie de Ciotat (between Marseille and Toulon), violent squalls can be felt in the lee during strong northwesterly winds (Hydrographer of the Navy, 1965).

Skies along the coast are usually clear. Precipitation is uncommon, except when the Mistral is shallow with a southerly flow at mid-levels that causes middle cloudiness and rain. Other exceptions are at the cold front associated with the onset of the Mistral and at secondary cold fronts associated with reintensification of Mistral conditions. However, as the cold air moves out over the warmer water, convective cloudiness increases. Poor atmospheric visibilities also have been reported up to a height of 100 ft (30 m) during cases of extremely strong Mistrals because of a layer of spray that extends above the water surface (Brody and Nestor, 1980).

8. Warnings

When the wind reaches, or is forecast to reach, force 6 (22-27 kt), a strong wind warning is issued from Toulon. It is carried on VHF Channel 16 and Marseille Radio. The Weather Bureau has 20 telephone lines for warning dissemination purposes. A coastal forecast can be obtained at telephone number 94-46-90-11. The offshore forecast number is 94-46-90-50.

A national meteorological station is established in Toulon about 1 1/2 mi east of the Fleet Landing. The

person in charge (in 1986) is Mr. René Mayencon. He speaks English well and is a very knowledgeable forecaster about Toulon and other ports of southern France. The address of the station is:

Station Météorologique
Avenue de la Mitre
83000 Toulon, France
Telephone 94-64-50-00

3.8.2 Non-Mistral

1. When clouds come from the south to southeast, Toulon is more cloudy/rainy than Marseille. When clouds come from the southwest rain starts first at Marseille.

2. Marseille is dry during southeast to northeast flow while Toulon is wet.

3. Easterly winds caused by a Genoa low are usually stronger than the pressure gradient indicates.

4. The early stages of lee cyclogenesis south of the Alps commonly results in southwesterly winds of 30-40 kt in the region between the southern French coast and Corsica (Brody and Nestor, 1980).

5. The rainy season at Toulon lasts from about 15 January to 15 March.

6. See section 3.8.1.8 (Warnings) above.

3.9 Summary of Problems, Actions, and Indicators

Table 3-5 is intended to provide easy to use seasonal references for meteorologists on ships using the Port of Toulon. Table 2-1 (section 2) summarizes Table 3-5 and is intended primarily for use by ship captains.

Table 3-5. Potential problem situations at Port of Toulon - ALL SEASONS

VESSEL LOCATION/SITUATION	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
1. Moored - inner harbor. Strongest in late Winter & early Spring Weakest in Summer Autumn	a. Mistral wind - Common W'ly (280°) wind. Strongest in afternoon, weakest just after midnight. Force 5 (17-21 kt) frequently experienced, force 8 (gale force, 34-40 kt) common, and force 11 (56-63 kt) reached occasionally. 100+ kt expected once each 20 years. Occurs year round but most common and strongest in late winter/early spring, weakest in summer. Commonly lasts 3-6 days but may be of shorter or longer duration.	a. Mistral winds can be very strong and persistent, but the inner harbor is considered safe; vessels should remain at their berths rather than sortie. Doubling of mooring lines may be required. Minimize personnel exposure on weather decks during a strong Mistral. Be aware of wind chill factor during winter and early spring. MISTRAL WINDS USUALLY INCREASE OVER THE WATER. MUCH STRONGER WINDS ARE USUALLY BLOWING 1-3 N MI OFFSHORE.	a. There are many guidelines concerning the causes, onset, intensity, duration, extent, frequency, and weather associated with the Mistral. Refer to section 2.8.1 of the accompanying text for an extensive discussion. When the wind reaches, or is forecast to reach force 6 (22-27 kt), a strong wind warning is issued from Toulon. It is carried on VHF Channel 16 and Marseille Radio. The Weather Bureau has 20 telephone lines for warning dissemination purposes. Forecasts are available at telephone numbers 94-46-90-11 (coastal) and 94-46-90-50 (offshore). The warmer the sea relative to the air, the stronger the offshore winds will be.
Winter Spring Uncommon in Summer Autumn	b. E to SE'ly wind - Usually caused by easterly moving extratropical cyclones passing south of Toulon or quasistationary low pressure center in Gulf of Genoa. Most common in winter/early spring, the winds may reach force 9 (41-47 kt).	b. Even though E to SE winds pose a greater hazard than the Mistral to harbor operations, vessels should remain in port rather than sortie. A 3/4 n mi breakwater reduces the effect of wave action in the inner harbor. Doubling of mooring lines may be required. Minimize personnel exposure on weather decks during a strong event. Rain likely.	b. Watch for an easterly tracking low pressure center passing south of Toulon or quasistationary low in the Gulf of Genoa. An easterly wind caused by a Genoa low is usually stronger that the gradient indicates. When the wind reaches, or is forecast to reach force 6 (22-27 kt), a strong wind warning is issued from Toulon. It is carried on VHF Channel 16 and Marseille Radio. The Weather Bureau has 20 telephone lines for warning dissemination purposes. Forecasts are available at telephone numbers 94-46-90-11 (coastal) and 94-46-90-50 (offshore).
2. Anchored - outer harbor. Strongest in late Winter & early Spring Weakest in Summer Autumn	a. Mistral wind - Common W'ly (280°) wind. Strongest in afternoon, weakest just after midnight. Force 5 (17-21 kt) frequently experienced, force 8 (gale force, 34-40 kt) common, and force 11 (56-63 kt) reached occasionally. 100+ kt expected once each 20 years. Occurs year round but most common and strongest in late winter/early spring, weakest in summer. Commonly lasts 3-6 days but may be of shorter or longer duration. Seas limited to 3 ft (1 m) at anchorage.	a. Past experience has shown that an aircraft carrier can find safe anchorage about 3/4 n mi S of Stalingrad Quay (where the Fleet Landing is located) during Mistral winds approaching 50 kt, so a sortie to find a more protected anchorage should not be required. Holding is excellent on a sand bottom. Lack of fetch limits wave height to about 3 ft (1 m) at the anchorage. Be aware of wind chill factor during winter and early spring. MISTRAL WINDS USUALLY INCREASE OVER THE WATER. MUCH STRONGER WINDS ARE NORMALLY BLOWING 1-3 N MI OFFSHORE.	a. There are many guidelines concerning the causes, onset, intensity, duration, extent, frequency, and weather associated with the Mistral. Refer to section 2.8.1 of the accompanying text for an extensive discussion. When the wind reaches, or is forecast to reach force 6 (22-27 kt), a strong wind warning is issued from Toulon. It is carried on VHF Channel 16 and Marseille Radio. The Weather Bureau has 20 telephone lines for warning dissemination purposes. Forecasts are available at telephone numbers 94-46-90-11 (coastal) and 94-46-90-50 (offshore). The warmer the sea relative to the air, the stronger the offshore winds will be.
Winter Spring Uncommon in Summer Autumn	b. E to SE'ly wind - Usually caused by easterly moving extratropical cyclones passing south of Toulon or quasistationary low pressure center in Gulf of Genoa. Most common in winter/early spring, the winds may reach force 9 (41-47 kt) and be accompanied by 16 ft (about 5 m) waves at the anchorage.	b. Strong E to SE winds can create waves to 16 ft (about 5 m) at the anchorage and waves to 40 ft (12 m) near the Port entrance. Moving to a more protected anchorage is recommended if a strong event is forecast. The Port of Marseille provides better protection from E to SE winds and waves, and is a likely alternative. Rain likely at Toulon.	b. Watch for an easterly tracking low pressure center passing south of Toulon or quasistationary low in the Gulf of Genoa. An easterly wind caused by a Genoa low is usually stronger than the gradient indicates. When the wind reaches, or is forecast to reach force 6 (22-27 kt), a strong wind warning is issued from Toulon. It is carried on VHF Channel 16 and Marseille Radio. The Weather Bureau has 20 telephone lines for warning dissemination purposes. Forecasts are available at telephone numbers 94-46-90-11 (coastal) and 94-46-90-50 (offshore).

Table 3-5. (Continued)

VESSEL LOCATION/SITUATION	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
3. Arriving/departing. Strongest in late Winter & early Spring Weakest in Summer Autumn	a. Mistral wind - Common W'ly (280°) wind. Strongest in afternoon, weakest just after midnight. Force 5 (17-21 kt) frequently experienced, force 8 (gale force, 34-40 kt) common, and force 11 (56-63 kt) reached occasionally. 100 + kt expected once each 20 years. Occurs year round but most common and strongest in late winter/early spring, weakest in summer. Commonly lasts 3-6 days but may be of shorter or longer duration.	a. Conditions encountered in the Port of Toulon cannot be considered representative of those that will be encountered seaward of the entrance to the Port, and vice versa; wind velocity and wave height will be higher at sea, with only 1-3 n mi making a big difference. Vessels departing the Port should be prepared for heavy weather. Inbound vessels will likely encounter reduced wind velocity and smaller waves as they enter the Port and progress to the anchorage/inner harbor. Be aware of wind chill factor during winter and early spring.	a. There are many guidelines concerning the causes, onset, intensity, duration, extent, frequency, and weather associated with the Mistral. Refer to section 2.8.1 of the accompanying text for an extensive discussion. When the wind reaches, or is forecast to reach force 6 (22-27 kt), a strong wind warning is issued from Toulon. It is carried on VHF Channel 16 and Marseille Radio. The Weather Bureau has 20 telephone lines for warning dissemination purposes. Forecasts are available at telephone numbers 94-46-90-11 (coastal) and 94-46-90-50 (offshore). The warmer the sea relative to the air, the stronger the offshore winds will be.
Winter Spring Uncommon in Summer Autumn	b. E to SE'ly wind - Usually caused by easterly moving extratropical cyclones passing south of Toulon or quasistationary low pressure center in Gulf of Genoa. Most common in winter/early spring, the winds may reach force 9 (41-47 kt) and be accompanied by 16 ft (about 5 m) waves at the anchorage. Waves to 40 ft (12m) are possible along the coast.	b. Vessels in Toulon harbor should schedule departure so strong E to SE winds and waves are avoided. Inbound vessels should delay arrival until after conditions abate, but once inbound vessels are committed, they should encounter no problems going through the inner harbor entrance, even with strong winds. Rain likely.	b. Watch for an easterly tracking low pressure center passing south of Toulon or quasistationary low in the Gulf of Genoa. An easterly wind caused by a Genoa low is usually stronger than the gradient indicates. When the wind reaches, or is forecast to reach force 6 (22-27 kt), a strong wind warning is issued from Toulon. It is carried on VHF Channel 16 and Marseille Radio. The Weather Bureau has 20 telephone lines for warning dissemination purposes. Forecasts are available at telephone numbers 94-46-90-11 (coastal) and 94-46-90-50 (offshore).
4. Small boats. Strongest in late Winter & early Spring Weakest in Summer Autumn	a. Mistral wind - Common W'ly (280°) wind. Strongest in afternoon, weakest just after midnight. Force 5 (17-21 kt) frequently experienced, force 8 (gale force, 34-40 kt) common, and force 11 (56-63 kt) reached occasionally. 100+ kt expected once each 20 years. Occurs year round but most common and strongest in late winter/early spring, weakest in summer. Commonly lasts 3-6 days but may be of shorter or longer duration. Seas limited to 3 ft (1 m) at the anchorage.	a. Small boat operations should be restricted to runs in the inner harbor and to/from the anchorage and Fleet Landing. Conditions become calmer near the shore. Be aware of wind chill factor during winter and early spring.	a. There are many guidelines concerning the causes, onset, intensity, duration, extent, frequency, and weather associated with the Mistral. Refer to section 2.8.1 of the accompanying text for an extensive discussion. When the wind reaches, or is forecast to reach force 6 (22-27 kt), a strong wind warning is issued from Toulon. It is carried on VHF Channel 16 and Marseille Radio. The Weather Bureau has 20 telephone lines for warning dissemination purposes. Forecasts are available at telephone numbers 94-46-90-11 (coastal) and 94-46-90-50 (offshore). The warmer the sea relative to the air, the stronger the offshore winds will be.
Winter Spring Uncommon in Summer Autumn	b. E to SE'ly wind - Usually caused by easterly moving extratropical cyclones passing south of Toulon or quasistationary low pressure center in Gulf of Genoa. Most common in winter/early spring, the winds may reach force 9 (41-47 kt) and be accompanied by 16 ft (about 5 m) waves at the anchorage.	a. Boating should be curtailed to/from the anchorage. Inner harbor operations should be limited to operationally necessary runs only. Rain likely.	b. Watch for an easterly tracking low pressure center passing south of Toulon or quasistationary low in the Gulf of Genoa. An easterly wind caused by a Genoa low is usually stronger than the gradient indicates. When the wind reaches, or is forecast to reach force 6 (22-27 kt), a strong wind warning is issued from Toulon. It is carried on VHF Channel 16 and Marseille Radio. The Weather Bureau has 20 telephone lines for warning dissemination purposes. Forecasts are available at telephone numbers 94-46-90-11 (coastal) and 94-46-90-50 (offshore).

REFERENCES

Brody, L. R. and M. J. R. Nestor, 1980: Regional Forecasting Aids for the Mediterranean Basin, NAVENVPREDRSCHFAC Technical Report TR 80-10. Naval Environmental Prediction Research Facility, Monterey, CA 93941.

Hydrographer of the Navy, 1965: Mediterranean Pilot, Volume II. Published by the Hydrographer of the Navy, London, England.

Kotsch, W. J., 1983: Weather for the Mariner, Third Edition. Naval Institute Press, Annapolis, MD.

Meteorological Office, Air Ministry, 1962: Weather in the Mediterranean, Volume I, General Meteorology. Her Majesty's Stationery Office, London, 372 pp.

NEPRF, 1977: Navy Tactical Applications Guide, Volume 2, Environmental Phenomena and Effects, TR77-04. Navy Environmental Prediction Research Facility, Monterey, CA.

NEPRF, 1980: Navy Tactical Applications Guide, Volume 3, North Atlantic and Mediterranean Weather Analysis and Forecast Applications, TR80-07. Navy Environmental Prediction Research Facility, Monterey, CA.

Reiter, E. C., 1971: Digest of Selected Weather Problems of the Mediterranean. NAVWEARSCHFAC Technical Paper No. 9-71. Naval Weather Research Facility, Bldg. R-48, Naval Air Station, Norfolk, Virginia 23511

PORT VISIT INFORMATION

JUNE 1986. NEPRF meteorologists R. Fett and R. Picard met with the Port Captain Mr. Jaouven to obtain much of the information included in this port evaluation.

APPENDIX A

General Purpose Oceanographic Information

This section provides general information on wave forecasting and wave climatology as used in this study. The forecasting material is not harbor specific. The material in paragraphs A.1 and A.2 was extracted from H.O. Pub. No. 603, Practical Methods for Observing and Forecasting Ocean Waves (Pierson, Neumann, and James, 1955). The information on fully arisen wave conditions (A.3) and wave conditions within the fetch region (A.4) is based on the JONSWAP model. This model was developed from measurements of wind wave growth over the North Sea in 1973. The JONSWAP model is considered more appropriate for an enclosed sea where residual wave activity is minimal and the onset and end of locally forced wind events occur rapidly (Thornton, 1986), and where waves are fetch limited and growing (Hasselmann, et al., 1976). Enclosed sea, rapid onset/subsiding local winds, and fetch limited waves are more representative of the Mediterranean waves and winds than the conditions of the North Atlantic from which data was used for the Pierson and Moskowitz (P-M) Spectra (Neumann and Pierson 1966). The P-M model refined the original spectra of H.O. 603, which over developed wave heights.

The primary difference in the results of the JONSWAP and P-M models is that it takes the JONSWAP model longer to reach a given height or fully developed seas. In part this reflects the different starting wave conditions. Because the propagation of waves from surrounding areas into semi-enclosed seas, bays, harbors, etc. is limited, there is little residual wave action following periods of locally light/calm winds and the sea surface is nearly flat. A local wind developed wave growth is therefore slower than wave growth in the open ocean where some residual wave action is generally always

present. This slower wave development is a built in bias in the formulation of the JONSWAP model which is based on data collected in an enclosed sea.

A.1 Definitions

Waves that are being generated by local winds are called "SEA". Waves that have traveled out of the generating area are known as "SWELL". Seas are chaotic in period, height and direction while swell approaches a simple sine wave pattern as its distance from the generating area increases. An in-between state exists for a few hundred miles outside the generating area and is a condition that reflects parts of both of the above definitions. In the Mediterranean area, because its fetches and open sea expanses are limited, SEA or IN- BETWEEN conditions will prevail. The "SIGNIFICANT WAVE HEIGHT" is defined as the average value of the heights of the one-third highest waves. PERIOD and WAVE LENGTH refer to the time between passage of, and distances between, two successive crests on the sea surface. The FREQUENCY is the reciprocal of the period (f = 1/T) therefore as the period increases the frequency decreases. Waves result from the transfer of energy from the wind to the sea surface. The area over which the wind blows is known as the FETCH, and the length of time that the wind has blown is the DURATION. The characteristics of waves (height, length, and period) depend on the duration, fetch, and velocity of the wind. There is a continuous generation of small short waves from the time the wind starts until it stops. With continual transfer of energy from the wind to the sea surface the waves grow with the older waves leading the growth and spreading the energy over a greater range of frequencies. Throughout the growth cycle a SPECTRUM of ocean waves is being developed.

A.2 <u>Wave Spectrum</u>

Wave characteristics are best described by means of their range of frequencies and directions or their <u>spectrum</u> and the shape of the spectrum. If the spectrum of the waves covers a wide range of frequencies and directions (known as short-crested conditions), <u>SEA</u> conditions prevail. If the spectrum covers a narrow range of frequencies and directions (long crested conditions), <u>SWELL</u> conditions prevail. The wave spectrum depends on the duration of the wind, length of the fetch, and on the wind velocity. At a given wind speed and a given state of wave development, each spectrum has a band of frequencies where most of the total energy is concentrated. As the wind speed increases the range of significant frequencies extends more and more toward lower frequencies (longer periods). The frequency of maximum energy is given in equation 1.1 where v is the wind speed in knots.

$$f_{max} = \frac{2.476}{v} \qquad (1.1)$$

The wave energy, being a function of height squared, increases rapidly as the wind speed increases and the maximum energy band shifts to lower frequencies. This results in the new developing smaller waves (higher frequencies) becoming less significant in the energy spectrum as well as to the observer. As larger waves develop an observer will pay less and less attention to the small waves. At the low frequency (high period) end the energy drops off rapidly, the longest waves are relatively low and extremely flat, and therefore also masked by the high energy frequencies. The result is that 5% of the upper frequencies and 3% of the lower frequencies can be cut-off and only the remaining

frequencies are considered as the "significant part of the wave spectrum". The resulting range of significant frequencies or periods are used in defining a fully arisen sea. For a fully arisen sea the approximate average period for a given wind speed can be determined from equation (1.2).

$$\bar{T} = 0.285v \tag{1.2}$$

Where v is wind speed in knots and T is period in seconds. The approximate average wave length in a fully arisen sea is given by equation (1.3).

$$\bar{L} = 3.41\ \bar{T}^2 \tag{1.3}$$

Where $\bar{L}$ is average wave length in feet and $\bar{T}$ is average period in seconds.

The approximate average wave length of a fully arisen sea can also be expressed as:

$$\bar{L} = .67\text{"L"} \tag{1.4}$$

where "L" = $5.12T^2$, the wave length for the classic sine wave.

A.3 Fully Arisen Sea Conditions

For each wind speed there are minimum fetch (n mi) and duration (hr) values required for a fully arisen sea to exist. Table A-1 lists minimum fetch and duration values for selected wind speeds, values of significant wave (average of the highest 1/3 waves) period and height, and wave length of the average wave during developing and fully arisen seas. The minimum duration time assumes a start from a flat sea. When pre-existing

lower waves exist the time to fetch limited height will be shorter. Therefore the table duration time represents the maximum duration required.

Table A-1. Fully Arisen Deep Water Sea Conditions Based on the JONSWAP Model.

Wind Speed (kt)	Minimum Fetch/Duration (n mi) / (hrs)	Sig Wave (H1/3) Period/Height (sec) / (ft)	Wave Length (ft)[1,2] Developing/Fully /Arisen L X (.5) /L X (.67)
10	28 / 4	4 / 2	41 / 55
15	55 / 6	6 / 4	92 / 123
20	110 / 8	8 / 8	164 / 220
25	160 / 11	9 / 12	208 / 278
30	210 / 13	11 / 16	310 / 415
35	310 / 15	13 / 22	433 / 580
40	410 / 17	15 / 30	576 / 772

NOTES:

[1] Depths throughout fetch and travel zone must be greater than 1/2 the wave length, otherwise shoaling and refraction take place and the deep water characteristics of waves are modified.

[2] For the classic sine wave the wave length (L) equals 5.12 times the period (T) squared ($L = 5.12T^2$). As waves develop and mature to fully developed waves and then propagate out of the fetch area as swell their wave lengths approach the classic sine wave length. Therefore the wave lengths of developing waves are less than those of fully developed waves which in turn are less than the length of the resulting swell. The factor of .5 (developing) and .67 (fully developed) reflect this relationship.

A.4 Wave Conditions Within The Fetch Region

Waves produced by local winds are referred to as SEA. In harbors the local sea or wind waves may create hazardous conditions for certain operations. Generally within harbors the fetch lengths will be short and therefore the growth of local wind waves will be fetch limited. This implies that there are locally determined upper limits of wave height and period for each wind velocity. Significant changes in speed or direction will result in generation of a new wave group with a new set of height and period limits. Once a fetch limited sea reaches its upper limits no further growth will occur unless the wind speed increases.

Table A-2 provides upper limits of period and height for given wind speeds over some selected fetch lengths. The duration in hours required to reach these upper limits (assuming a start from calm and flat sea conditions) is also provided for each combination of fetch length and wind speed. Some possible uses of Table A-2 information are:

1) If the only waves in the area are locally generated wind waves, the Table can be used to forecast the upper limit of sea conditions for combinations of given wind speeds and fetch length.

2) If deep water swell is influencing the local area in addition to locally generated wind waves, then the Table can be used to determine the wind waves that will combine with the swell. Shallow water swell conditions are influenced by local bathymetry (refraction and shoaling) and will be addressed in each specific harbor study.

3) Given a wind speed over a known fetch length the maximum significant wave conditions and time needed to reach this condition can be determined.

Table A-2. Fetch Limited Wind Wave Conditions and Time Required to Reach These Limits (Based on JONSWAP Model). Enter the table with wind speed and fetch length to determine the significant wave height and period, and time duration needed for wind waves to reach these limiting factors. All of the fetch/speed combinations are fetch limited except the 100 n mi fetch and 18 kt speed.

Format: height (feet)/period (seconds)
duration required (hours)

Fetch Length (n mi) \ Wind Speed (kt)	18	24	30	36	42
10	2/3-4 1-2	3/3-4 2	3-4/4 2	4/4-5 1-2	5/5 1-2
20	3/4-5 2-3	4/4-5 3	5/5 3	6/5-6 3-4	7/5-6 3
30	3-4/5 3	5/5-6 4	6/6 3-4	7/6 3-4	8/6-7 3
40	4-5/5-6 4-5	5/6 4	6-7/6-7 4	8/7 4	9-10/7-8 3-4
100	5/6-7[1] 5-6	9/8 8	11/9 7	13/9 7	15-16/9-10 7

[1] 18 kt winds are not fetch limited over a 100 n mi fetch.

An example of expected wave conditions based on Table A-2 follows:

<u>WIND FORECAST OR CONDITION</u>

An offshore wind of about 24 kt with a fetch limit of 20 n mi (ship is 20 n mi from the coast) is forecast or has been occurring.

<u>SEA FORECAST OR CONDITION</u>

From Table A-2: If the wind condition is forecast to last, or has been occurring, for at least 3 hours:

Expect sea conditions of 4 feet at 4-5 second period to develop or exist. If the condition lasts less than 3 hours the seas will be lower. If the condition lasts beyond 3 hours the sea will not grow beyond that developed at the end of about 3 hours unless there is an increase in wind speed or a change in the direction that results in a longer fetch.

A.5 Wave Climatology

The wave climatology used in these harbor studies is based on 11 years of Mediterranean SOWM output. The MED-SOWM is discussed in Volume II of the U.S. Naval Oceanography Command Numerical Environmental Products Manual (1986). A deep water MED-SOWM grid point was selected as representative of the deep water wave conditions outside each harbor. The deep water waves were then propagated into the shallow water areas. Using linear wave theory and wave refraction computations the shallow water climatology was derived from the modified deep water wave conditions. This climatology does not include the local wind generated seas. This omission, by design, is accounted for by removing all wave data for periods less than 6 seconds in the climatology. These shorter period waves are typically dominated by locally generated wind waves.

A.6 Propagation of Deep Water Swell Into Shallow Water Areas

When deep water swell moves into shallow water the wave patterns are modified, i.e., the wave heights and directions typically change, but the wave period remains constant. Several changes may take place including shoaling as the wave feels the ocean bottom, refraction as the wave crest adjusts to the bathymetry pattern, changing so that the crest becomes more parallel to the bathymetry contours, friction with the bottom sediments, interaction with currents, and adjustments caused by water temperature gradients. In this work, only shoaling and refraction effects are considered. Consideration of the other factors are beyond the resources available for this study and, furthermore, they are considered less significant in the harbors of this study than the refraction and shoaling factors.

To determine the conditions of the deep water waves in the shallow water areas the deep water

conditions were first obtained from the Navy's operational MED-SOWM wave model. The bathymetry for the harbor/area of interest was extracted from available charts and digitized for computer use. Figure A-1 is a sample plot of bathymetry as used in this project. A ray path refraction/shoaling program was run for selected combinations of deep water wave direction and period. The selection was based on the near deep water wave climatology and harbor exposure. Each study area requires a number of ray path computations. Typically there are 3 or 4 directions (at 30° increments) and 5 or 6 periods (at 2 second intervals) of concern for each area of study. This results in 15 to 24 plots per area/harbor. To reduce this to a manageable format for quick reference, specific locations within each study area were selected and the information was summarized and is presented in the specific harbor studies in tabular form.

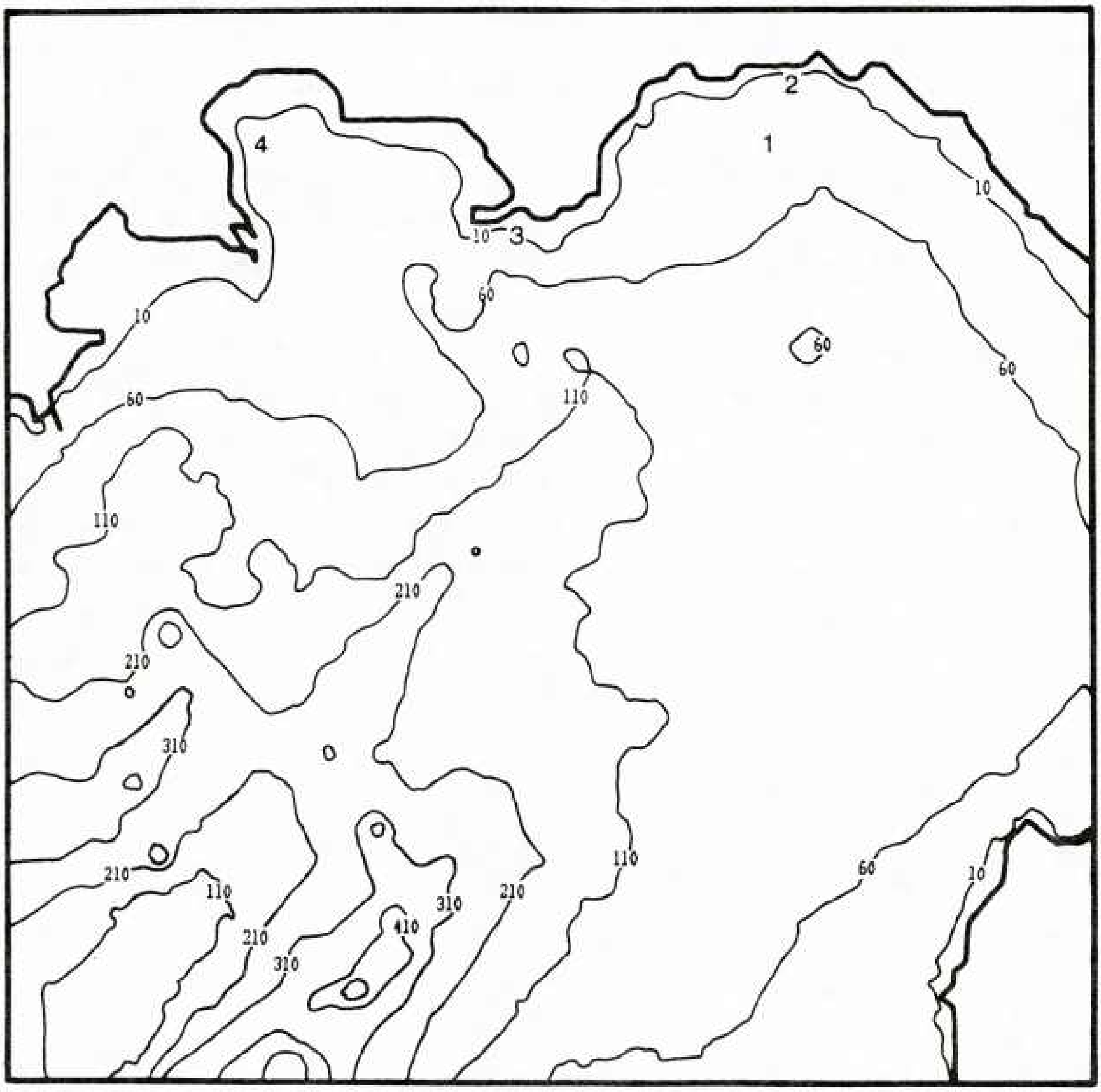

Figure A-1. Example plot of bathymetry (Naples harbor) as used in this project. For plotting purposes only, contours are at 50 fathom intervals from an initial 10 fathoms to 110 fathoms, and at 100 fathom intervals thereafter. The larger size numbers identify specific anchorage areas addressed in the harbor study.

REFERENCES

Hasselmann, K. D., D. B. Ross, P. Muller, and W. Sell, 1976: A parametric wave prediction model. J. Physical Oceanography, Vol. 6, pp. 208-228.

Neumann, G., and W. J. Pierson Jr., 1966: Principles of Physical Oceanography. Prentice-Hall, Englewood Cliffs.

Pierson, W. J. Jr., G. Neumann, and R. W. James, 1955: Practical Methods for Observing and Forecasting Ocean Waves, H. O. Pub. No. 603.

Thornton, E. B., 1986: Unpublished lecture notes for OC 3610, Waves and Surf Forecasting. Naval Postgraduate School, Monterey, CA.

U. S. Naval Oceanography Command, 1986: Vol. II of the U. S. Naval Oceanography Command Numerical Environmental Products Manual.

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